rican Denture Society Meeting, Chicago, Illinois, January 31 and February 1, 1958.
rican Academy of Restorative Dentistry Meeting, Chicago, Illinois, February 1 and 2, 1958.
rican Academy of Crown and Bridge Prosthodontics Meeting, Chicago, Illinois, February 1 and 2, 1958.

THE JOURNAL OF PROSTHETIC DENTISTRY

VOLUME 8 JANUARY, 1958 NUMBER 1

UNIVERSITY OF MICHIGAN
JAN 22 1958
DENTISTRY LIBRARY

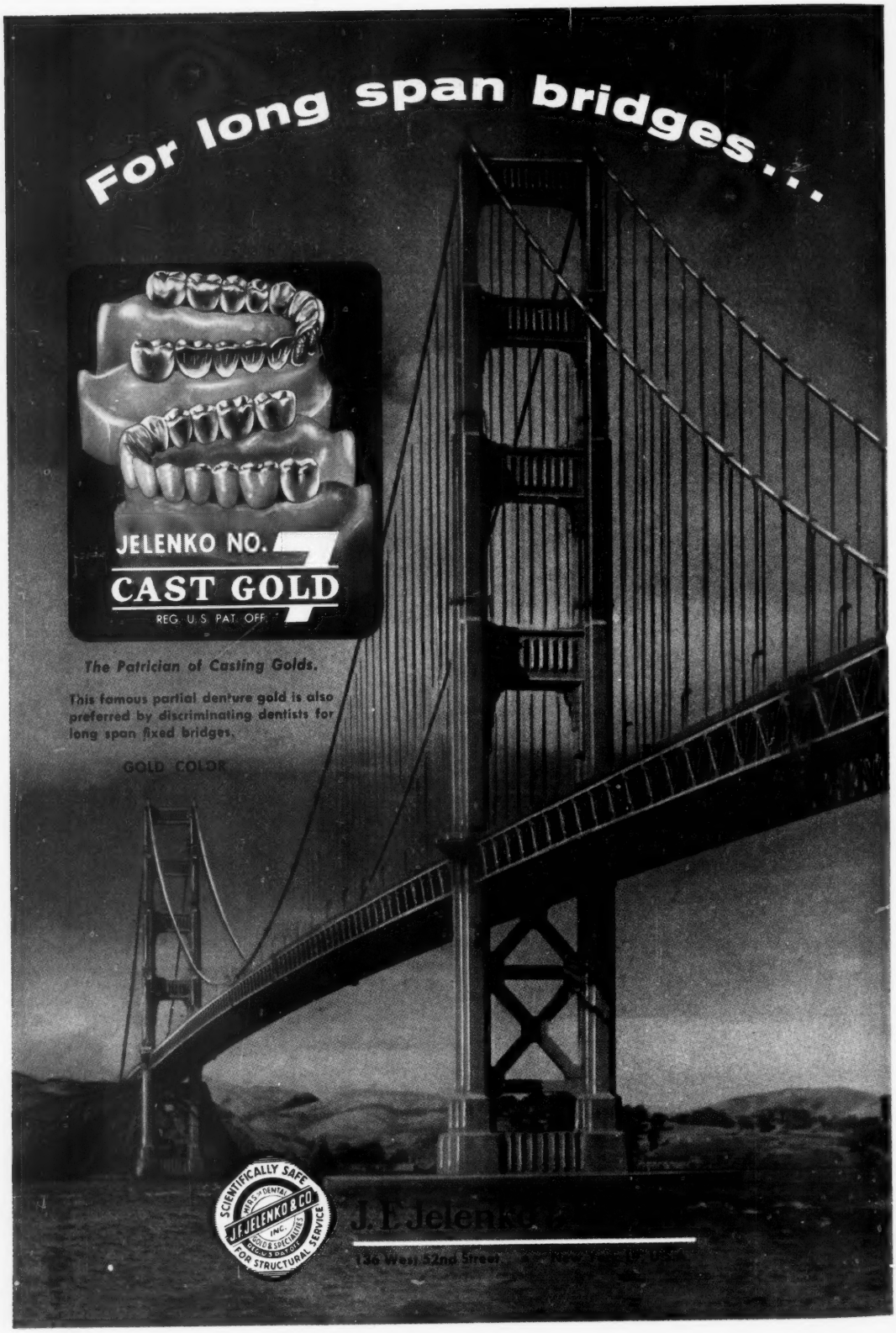
COMPLETE DENTURES
REMOVABLE PARTIAL DENTURES
FIXED PARTIAL DENTURES
OPERATIVE DENTISTRY

Official Publication of

THE ACADEMY OF DENTURE PROSTHETICS
THE AMERICAN DENTURE SOCIETY
THE PACIFIC COAST SOCIETY OF PROSTHODONTISTS
THE AMERICAN ACADEMY OF RESTORATIVE DENTISTRY
THE AMERICAN ACADEMY OF CROWN AND BRIDGE PROSTHODONTICS
THE GREATER NEW YORK ACADEMY OF PROSTHODONTICS

PUBLISHED BY
THE C. V. MOSBY COMPANY, 3207 WASHINGTON BLVD., ST. LOUIS 3, U.S.A.

TABLE OF CONTENTS ON PAGE ONE


For long span bridges...
JELENKO NO. 7
CAST GOLD
REG. U.S. PAT. OFF.
The Patrician of Casting Golds.
This famous partial denture gold is also preferred by discriminating dentists for long span fixed bridges.
GOLD COLOR
SCIENTIFICALLY SAFE
J.F. JELENKO & CO. INC.
FOR STRUCTURAL SERVICE
136 West 52nd Street

THE JOURNAL OF
PROSTHETIC
DENTISTRY

DENTAL LIBRARY
RK
1
J867

CONTENTS FOR JANUARY, 1958

Through the Eyes of the Editor.
Carl O. Boucher, D.D.S., Columbus, Ohio 1

In Memoriam. Alfred Gysi, Prof. Dr.med.h.c., 1865-1957.
I. Lester Furnas, D.D.S., La Jolla, Calif. 6

Geriatrics and the Denture Patient.
Charles H. Jamieson, D.D.S., Detroit, Mich. 8

The Rubber Base Impression Materials.
O. M. Dresen, D.D.S., Milwaukee, Wis. 14

Frenoplasty.
John H. Lee, Dip.D.S., L.D.S., R.C.S. (Eng.), and David Downton, F.D.S., R.C.S. (Eng.), London, England 19

Repositioning of the Sublingual Fold for Complete Dentures.
E. T. Lewis, D.D.S., Pittsburgh, Pa. 22

Preparation of Casts for Immediate Dentures.
Stanley G. Standard, D.D.S., New York, N. Y. 26

Vertical Dimension and Centric Jaw Relation in Complete Denture Construction.
Earle S. Smith, D.D.S., Iowa City, Iowa 31

Hinge Axis Registration: Experiments on the Articulator.
Olle Borgh, L.D.S., and Ulf Posselt, L.D.S., Odont. Dr., Malmö, Sweden 35

A Contribution to the Study of the Movements of the Mandible.
Norman G. Bennett, M.B., L.D.S. 41

Dentist, Dental Laboratory, and the Patient.
A. H. Grunewald, D.D.S., M.S., Chicago, Ill. 55

Developments in the Denture Field During the Past Half Century.
Victor H. Sears, D.D.S., Vallejo, Calif. 61

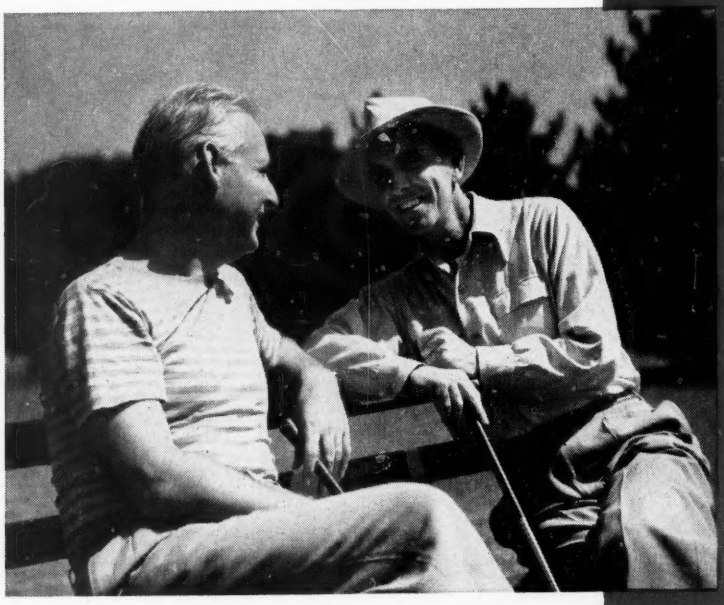
Discussion of Developments in the Denture Field During the Past Half Century by Victor H. Sears, D.D.S.
O. M. Dresen, D.D.S., Milwaukee, Wis. 68

Contemporary Partial Denture Designs.
William L. McCracken, D.D.S., M.S., Birmingham, Ala. 71

Internal Attachment for Fixed Removable Partial Dentures.
Irwin J. Plotnick, D.D.S., Glenside, Pa. 85

(Continued on page 3)

THESE DENTURES PASS THE "ASSOCIATION TEST"



WHEN DENTURES ARE "POLIDENT CLEAN" THEY REFLECT MORE CREDIT UPON YOUR SKILL

POLIDENT offers the easy, safe way to keep dentures clean, fresh, sparkling . . . free of stains, scratches, odor. Just *soak-rinse-wear.* No harsh scrubbing to damage lustrous surfaces or delicate features; POLIDENT floats away debris, removes stains—*within 5 minutes.*

Recommended by more dentists than any other cleanser

POLIDENT®

For office supply of free samples, write—

BLOCK DRUG COMPANY, INC.

105 Academy Street • JERSEY CITY 2, N.J.

Contents for January, 1958—Continued

A Method for Registering Occlusion in Semiedentulous Mouths.
John H. Emmert, D.D.S., Cleveland, Ohio **94**

Flexible Rubber Molds for Accurate Multiple Reproduction of Plaster Casts.
Philip R. Joram, Helen T. Grogan, and Samuel Pruzansky, D.D.S., Bethesda, Md. **100**

Clinical Uses of Rubber Impression Materials and Electroforming of Casts and Dies in Pure Silver.
W. Campbell Hudson, D.D.S., New York, N. Y. **107**

The Disclosure of Cleavage and Fracture Lines in Porcelain Restorations.
Maurice J. Saklad, D.D.S., New York, N. Y. **115**

Porcelain Veneers Bonded to Gold Castings—A Progress Report.
John F. Johnston, D.D.S., R. W. Dykema, D.D.S., and D. M. Cunningham, D.D.S., Indianapolis, Ind. **120**

The Use of Rubber Base Impression Materials in the Construction of Inlays.
Mortimer C. Davis, D.D.S., Jersey City, N. J. **123**

Ultrasonics in Dentistry.
William Lefkowitz, D.D.S., Columbus, Ohio **135**

Effects of Ultrasonic Cavity Preparation Upon the Pulp.
Helmut A. Zander, M.S., D.D.S., Rochester, N.Y. **137**

Ultrasonic Cavity Preparation: Effect on the Immature Dentition.
Leo Zach, D.D.S., New York, N. Y. **139**

The Effect of Ultrasonic Energy on the Periodontal Membrane, Alveolar Bone, and Gingivae.
Rollin E. Mallernee, D.D.S., M.Sc., Loma Linda, Calif. **147**

Ultrasonic Cavity Preparation.
Harry H. Postle, D.D.S., Columbus, Ohio **153**

The Use of Ultrasonics in Periodontal Treatment.
John R. Wilson, D.D.S., Columbus, Ohio **161**

Ultrasonic Techniques for Crown and Bridge Retainers.
Stanley D. Tylman, D.D.S., M.S., Chicago, Ill. **167**

Comparative Evaluation of Newer Devices and Techniques for the Removal of Tooth Structure.
Jack L. Hartley, Major, USAF (DC), Randolph Air Force Base, Texas **170**

Condensation of Amalgam With Ultrasonic Vibration.
Eugene W. Skinner, Ph.D., and Gena T. Mizera, Chicago, Ill. **183**

SIXTH ANNUAL ESSAY CONTEST **195**

SPECIAL ANNOUNCEMENT **197**

READERS' ROUND TABLE **198**

BOOK REVIEWS **199**

NEWS AND NOTES **200**

Vol. 8, No. 1, January, 1958. Journal of Prosthetic Dentistry is published bi-monthly by the C. V. Mosby Company, 3207 Washington Blvd., St. Louis 3, Mo. Subscription rates: United States and Its Possessions $12.00, Students $6.00; Canada, Latin-America, and Spain $12.50, Students $6.50; Other Countries $13.00, Students $7.00. Single copies, $2.50 postpaid. Entered as second-class matter March 13, 1951 at the Post Office at St. Louis, Missouri, under the Act of March 3, 1879. Additional entry authorized at Jefferson City, Missouri. Printed in the U. S. A.

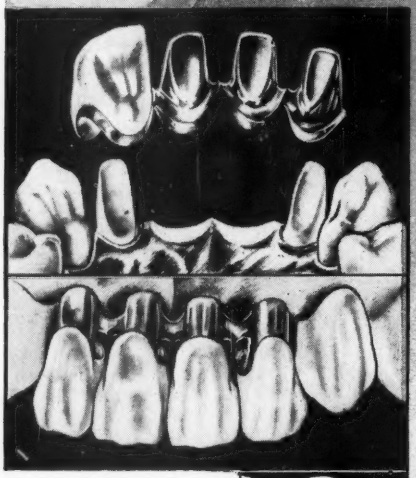
Copyright © 1958 by the C. V. Mosby Co.

Glamorous but PRACTICAL

VACUUM FIRED*

THE NU-DENT (Reg. U.S. Pat. Off.) UNIT-BILT

porcelain jacket crown bridge



The Nu-Dent "Unit-Bilt" Porcelain Jacket Crown Bridge is an ingeniously designed porcelain bridge that affords the ultimate in esthetic beauty . . . an ideal anterior restoration for as many as 8 teeth. . . . It is a multiple correction restoration supported on an invisible cast gold base which carries a core for each jacket. Each replacement tooth is an individually carved Porcelain Jacket Crown, cemented to its individual core—*As a result, any tooth can be replaced in the mouth without removing the bridge!*

The Nu-Dent "Unit-Bilt" Porcelain Jacket Crown Bridge has been used with utmost success in tens of thousands of cases over a period of more than 25 years . . . a typical example of Nu-Dent leadership in the development of "*glamorous—but practical*" porcelain restorations.

YOUR INSURANCE: With each finished case a permanent duplicate model of the gold frame is supplied with individual amalgam dies for accurate jacket replacement in case of fracture.

Send the coupon for detailed information.

*ALL NU-DENT RESTORATIONS ARE VACUUM-FIRED UNDER A PATENTED VACUUM-FIRING FURNACE TECHNIQUE.

NU-DENT PORCELAIN STUDIO, Inc.
(Reg. U.S. Pat. Office)
220 W. 42 St., New York 36, N. Y.
9615 Brighton Way, Beverly Hills, Cal.
(Send coupon to nearest studio)

NU-DENT PORCELAIN STUDIO, Inc.
Please send information on NU-DENT porcelain restorations.
Dr._____
ADDRESS_____
CITY & ZONE_____ STATE_____

The Vacuum Fired Meta-por (Reg. U.S. Pat. Off.) porcelain-fused-to-gold restoration is NU-DENT'S latest development in "glamorous-but-practical" restorations. The strength and adaptability of gold are *successfully* combined with the natural beauty of porcelain!

THE JOURNAL OF
PROSTHETIC
DENTISTRY

JANUARY, 1958
VOLUME 8
NUMBER 1

THROUGH THE EYES OF THE EDITOR

Charles H. Jamieson discusses the problems associated with treating the aging denture patient. This is a matter of increasing concern in the practice of dentistry because of the number of elderly people who require denture service. The statistics he presents are surprising to say the least. He lists many possible oral and general disorders of the aging person and suggests treatments for the disorders. The importance of nutrition in these persons cannot be overestimated, and the psychologic encouragement which should be afforded to them by dentists is of almost equal importance. As he suggests, these people of advanced age need someone to *care* about them.

O. M. Dresen reports the results of his clinical experience with the rubber base impression materials for complete dentures. He points out the fact that the impression material alone will not be adequate and that it can be used successfully for complete denture impressions only when it is used with a thorough understanding of the anatomy of the mouth. This is a logical approach to the use of *any* new impression material. He describes the technique which he uses and observes that a very high percentage of mandibular dentures made over casts from these rubber base impressions were successful. This success may be related to the technical skill used in making the impressions as well as to the inherent qualities of the impression materials used.

John H. Lee and David Downton describe their surgical technique for eliminating a troublesome frenum. The procedure seems to be simple, effective, and practical. It should not be necessary in most instances but would be indicated only if the frenum were attached too closely to the occlusal surface of the ridge.

E. T. Lewis suggests that the surgical treatment of the anterior part of the floor of the mouth will simplify the prosthetic treatment of patients who have unfavorable conditions in this region. He describes the technique for developing or enlarging the space available for the anterior part of the lingual flange of the lower denture. The critical part of the technique is the mucous membrane graft used for the prevention of disturbing scar tissue formation. The procedure seems to be quite radical, and, even though it may be of value for some patients, it should not be attempted if it is not necessary.

Stanley G. Standard discusses the preparation of casts for immediate dentures and describes the techniques he uses for the various steps in making immediate dentures. The procedure permits an accurate control of the amount of surgery to be done at the time of insertion of the dentures.

Earle S. Smith discusses jaw relations in complete denture construction. He emphasizes the importance of determining the vertical dimension of occlusion accurately. He considers the vertical dimension of occlusion as a component part of centric relation. He favors the use of simple methods in obtaining these records and describes some pro-

cedures which would assist in getting the mandible into the desired position. He feels that it is essential to have the vertical dimension of occlusion established before centric relation is recorded. This is important because the horizontal relationship of the *body* of the mandible to the maxillae changes with different interarch distances even though the condyles are kept in the most posterior positions in their fossae.

Olle Borgh and Ulf Posselt report on their experiments relating to the hinge axis of the mandible. They conducted these experiments on a Hanau Model H articulator, and, from them, they conclude that a hinge movement could not be recorded accurately from this articulator without error. Even though they took elaborate precautions against psychologic errors, it is possible that a bend in the axis shaft of the test instrument could have produced the results they found. Also, it is noteworthy that the axis shaft was elongated, which would tend to magnify any errors which might be present in the instrument design. The test seems to be one of the accuracy of the machine work on the instrument rather than one of the validity of a hinge axis registration.

Norman G. Bennett reported on his experiments and study of the movement of the mandible in 1908. Since that time, many conflicting concepts regarding the "Bennett Movement" have developed. Much controversy and some confusion has resulted from the different interpretations of the ideas first expressed in this article. It is to be hoped that, by reprinting it exactly as it was published originally, the dental profession can reappraise its concepts of the "Bennett Movement" and possibly eliminate one facet of controversy.

A. H. Grunewald discusses the various responsibilities of dentists and dental laboratories as they affect the welfare of patients. He points out the fact that some dentists fail to accept their own responsibilities and attempt to shift them to the laboratories. It is very unfortunate that this is true because, in the long run, it is the patients who suffer, and the dental profession loses some of the respect it has earned through the years. He suggests a number of ways in which a better mutual understanding can be achieved. One of these appears to be extremely important. This is in the undergraduate training in prosthodontics. The basic background necessary for prosthodontics is so complicated that it involves a thorough understanding of the basic sciences, and it also involves the achievement of considerable skill in its technical phases. If the student is not given the necessary basic training and experience while he is in school, he will be susceptible to various fads, and as a result his patients will suffer after he becomes a dentist working without supervision. Prosthodontics is not the purely mechanical or technical entity that some dental educators seem to be implying. Prosthodontics offers the opportunity for the application of more routine daily use of the basic biologic and physical sciences taught in dental schools than most of the other branches of dentistry. The dentist must have a thorough knowledge and training in these aspects of his professional work. If he does, he can direct the work of the laboratory technician intelligently and can earn the respect of the technician and the patient. If he abdicates this responsibility, he does not deserve the respect of either. The suggestion of "proof steps" in laboratory operations is excellent, and they should be established to provide a closer working arrangement between the dentist and the laboratory technician. Since this close cooperation is desirable, it would be logical for the dental profession and the dental schools to provide at least the guidance for the education and training of dental laboratory technicians. Unless the dental profession accepts this responsibility, it is in no position to criticize the work done by the laboratories.

Victor H. Sears reviews the developments in prosthodontics during the past fifty years. This review is very enlightening because, as a rule, changes occur so gradually that the past is soon forgotten. The progress and improvement in equipment, materials, and methods is truly amazing. The rugged individualists who have contributed so much to this progress should not be forgotten.

O. M. Dresen correlates the progress of dental education with the developments made in prosthodontics during the past fifty years. It is obvious that the two are related, and, therefore, it is important that the trends in dental education should be consistent with the best interests of the people. Until such a time as all dental caries can be prevented,

until periodontal disease can be prevented, and until accidental injury to teeth and jaws can be prevented, dental education must supply the necessary training to dental students so the damage from these sources can be treated successfully.

William L. McCracken discusses various designs of partial dentures and shows how dentists and dental laboratory technicians can work together to fabricate successful partial dentures. He makes important distinctions between the relative responsibilities of the dentists and the laboratory technicians and places the greatest burden on the dentist. This is as it should be. Since the dentist determines which teeth may be retained and which must be removed, he determines the *basic design* of every partial denture. The laboratory technician may then apply mechanical principles to the fabrication of the appliances so long as he follows the basic design prescribed by the dentist. It is obvious that the dentist must have the various *mechanical* possibilities in mind when he determines which teeth may be retained safely. The author sets up sound specifications for the various components of partial dentures. If both the dentist and the laboratory technician develop the equivalent of these specifications, the quality of the partial denture service is almost certain to be adequate. Even though there may be honest differences of opinion regarding some aspects of the mechanical details, a sound basic design and the correct application of the various mechanical components of partial dentures will produce good serviceable restorations.

Irwin J. Plotnick describes an ingenious locking device for retaining small removable partial dentures and the technique for its use. It is apparent that the esthetic values of an appliance in which it is used would approach those of a fixed partial denture. The mechanics of retention require abutment teeth at both ends of the edentulous area, and the adjacent tooth surfaces must be protected from dental caries. It seems that the appliance would be held firmly, provided the periodontal support of the abutment teeth could be maintained so as to prevent their movement.

John H. Emmert points out the error of mounting casts by using the occlusal surfaces of teeth as the guide and suggests a technique which is designed to overcome this error. He points out the fact that errors in occlusion may cause soreness under denture bases of partial dentures. He describes an instrument for testing various interocclusal records and suggests the use of zinc oxide and eugenol pastes for making these records. The method is sound, but it requires definite control of the patient's jaw movement and position by the dentist.

Philip R. Joram, Helen T. Grogan, and Samuel Pruzansky describe a technique for making flexible rubber molds. These molds can be used for reproducing the complicated shapes which are characteristic of cleft palate conditions and could be used also in the preparation of clinical demonstration material.

W. Campbell Hudson describes his techniques for using rubber base impression materials for various prosthodontic operations. Properly used and controlled, these materials have definite advantages over some of the other impression materials. Apparently, one of the advantages is the comparative ease of silver plating for the production of dies with metal working surfaces. The fact that errors in tooth or cavity preparations are obvious in these impressions should be considered an advantage.

Maurice J. Saklad describes a method for testing porcelain restorations for defects. Its use could avoid serious difficulties by detecting the defects before the restorations are inserted. It does not seem to be too complicated to be practical.

John F. Johnston, R. W. Dykema, and D. M. Cunningham make a progress report on the clinical results of restorations with porcelain veneers baked on gold. The major problem in the use of these materials seems to be that of color accuracy. They make some practical suggestions which should prove helpful and indicate that the prospects are good for the eventual solution of the problem.

Mortimer C. Davis discusses the relative merits of various techniques for making gold inlays and describes in detail the technique for using the rubber base impression materials for this purpose. These new elastic impression materials certainly show promise of simplifying the procedures used to restore individual teeth. It should be noted that care and attention to detail are

essential parts of any technique if the results are to be successful.

William Lefkowitz introduces the report of the recent Symposium on the use of ultrasonic vibrations in dentistry. He points to the need for continuing research in this field. Extra pages have been added to the operative dentistry section of this issue of the JOURNAL OF PROSTHETIC DENTISTRY in order that a complete report of the Symposium could be made. Future issues of the JOURNAL OF PROSTHETIC DENTISTRY will include discussions of other problems and methods used in operative dentistry. In reality, these are also problems and methods of prosthodontics, since they are involved in the preparation of oral structures for the restoration of all or part of the missing structures of the oral cavity.

Helmut A. Zander reports on his experiments to determine the effect of ultrasonic vibrations upon the pulps of teeth of monkeys. His results apparently differ from those of some other investigators. The need for further research in this direction is obvious. Zander's experiments related to the more or less immediate effects upon the pulp. We wonder if they should not be correlated with bacteriologic examinations of the finished cavity preparations. This might show whether this tooth-cutting method "cleans" the cavity from caries as well as or better than other cutting methods do. It should be determined whether the ultrasonic vibrations drive the caries into the tooth or if it is completely removed.

Leo Zach reports on the effects of ultrasonic cavity preparations on the immature dentition. Information about this is rather important because the lack of discomfort to the patient would appeal to children. If the pulps of young teeth were damaged by the technique, it should not be used. His results showed no damage to the deciduous teeth of monkeys or to their partially formed permanent successors.

Rollin E. Mallernee investigated the effects of ultrasonic vibrations on the bone, periodontal membrane, and gingivae around teeth that have been treated by this technique. He examined these tissues after cavities had been prepared in the teeth and after they had been scaled. His results indicate no damage to any of these tissues as a result of cavity preparation or scaling by ultrasonic energy.

Harry H. Postle describes his technique for making cavity preparations by means of ultrasonic vibrations. The step-by-step procedure appears to be simple and practical. The dentist who uses this new equipment must establish a routine sequence of steps in its use in order to attain the best results with it.

John R. Wilson describes his technique for using the special ultrasonic device for periodontal treatment. He found that it was effective for removing thick hard deposits from teeth but that it was not as effective for removing thin stains as some other methods. He reports that the enamel of the teeth was not damaged by the instruments.

Stanley D. Tylman reports on the use of the ultrasonic technique for the preparation of teeth for complete and partial crowns. Since these preparations require the removal of large amounts of enamel, the procedure could be very effective. The difficulty seems to be a lack of a more or less standardized technique. More research is needed in this direction.

Jack L. Hartley reports on the clinical effectiveness of the newer devices for removing tooth structure. The factors considered were the cutting time, over-all time of operation, the vibrations transmitted to the skull, and the patient response. The observations and measurements were made on many patients and for many different types of preparations. It is significant that there was considerable variation in the results with the different methods. The effects of these variations are not limited to the patients. The dentist is likewise affected. The over-all effectiveness rating as it relates to the efficiency of patients before and after dental operations is most interesting. This could be one of the major bases for the choice of cutting instruments.

Eugene W. Skinner reports his tests on the condensation of silver amalgams by means of ultrasonic vibrations. The results provide guidance for the development of the technique for using the equipment for this purpose, and they indicate that amalgams condensed by this method are definitely stronger after one hour than those condensed manually. After one week, the difference in strength is less significant.

—Carl O. Boucher.

IN MEMORIAM

ALFRED GYSI, PROF. DR.MED.H.C.

1865-1957

WHENEVER AND AS OFTEN as some future historian may choose to record the origin and development of the dental profession, there will be one established fact universally recognized, and that will be the all-important part contributed by Dr. Alfred Gysi of Zürich, Switzerland.

Though a young profession, dentistry has contributed beyond its share of master minds to the health and happiness of mankind and, in this select group of great leaders, there stands none higher than the name of Gysi.

Alfred Gysi was born Aug. 31, 1865, at Aaran, Switzerland. His father was a photographer of note and a manufacturer of drawing instruments. Young Gysi finished his local schooling which was comparable to the American elementary and high schools and, at the age of 18, entered the University of Geneva where he graduated in 1886.

At the University, he majored in biologic and histologic subjects in preparation for a course in dentistry in which he enrolled the following year at the University of Pennsylvania.

It was during his attendance at the University of Pennsylvania that he developed his inclination for scientific research. Here he received great stimulation from his two favorite teachers, Dr. Brubaker and Dr. C. N. Peirce, and upon every available occasion during the rest of his long and eventful life, he never failed to give credit and thanks to these two fine men.

In his graduation thesis, he advocated the chemicoparasitic theory of tooth decay and used a series of microscopic pictures to prove his theory, all of which was quite new and revolutionary at that time. Following his graduation, he returned to Switzerland where he continued his research in his chosen profession of dentistry.

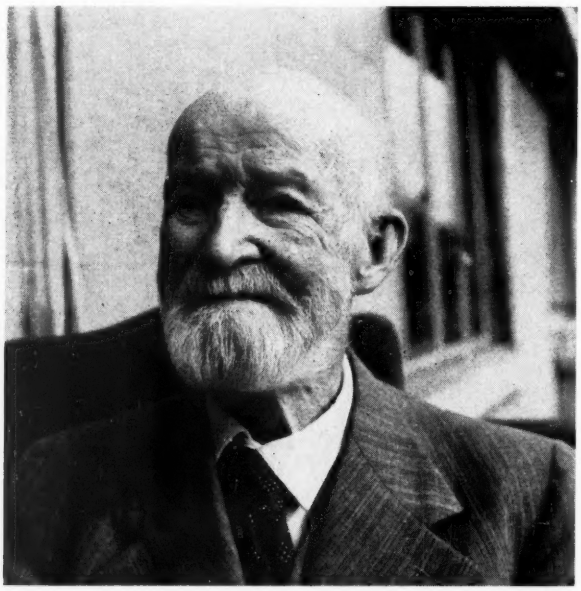
He was most fortunate in being able to associate himself at different times with some of the most experienced and finest thinkers in Europe, each of whom recognized in Dr. Gysi a student of exceptional native ability, and each contributed greatly to his expanding basic knowledge.

Dr. Gysi's early research efforts were mostly along the line of dental histology, and many of his findings and published papers were steppingstones to our modern histologic knowledge.

In 1891, Dr. Gysi established his own office and practice in Zürich. The actual practice of dentistry had little appeal to Dr. Gysi, but it gave him an opportunity

for experimentation in practical applications of scientific theories, and it served as a means of helping him to finance his many lines of research. Success was never enough for Dr. Gysi. His interests lay in the reasons for success and the frequency and cause of failures.

Dr. Jacob Billeter induced Dr. Gysi to accept a part-time association with the University of Zürich. This proved to be an extremely advantageous association, for here, under ideal associations and working conditions, he was able to pursue his scientific investigations. The science of histology became his specialty, and his major efforts were along this line until the turn of the century when, by chance, he became interested in the problems of occlusion and prosthetic dentistry. He then turned his attention to this branch of dentistry and became one of the world's leading authorities in it.



ALFRED GYSI. *(Photograph by Dr. Ralph Boos, Aug. 31, 1957.)*

Dr. Gysi by no means limited his interests and attention to the profession of dentistry. He developed and held the original patent rights on color photography in Europe. He did much original work in developing microphotography and stereoscopic photography.

He owned one of the most complete collections of stamps in Switzerland, and his collection of mounted butterflies was well known throughout Europe.

He was an amateur astronomer of considerable note and, when the department of astronomy in the University of Zürich needed a telescope, Dr. Gysi cast and ground the optics and built the entire instrument which is in use there at the present time.

His interests in botany were very extensive, and he was the first to solve and publish the geometric construction of the alpine daisy.

During World War I, Dr. Gysi was suspected by the Germans of being unfriendly to their cause, and he was placed under house arrest. Such inactivity was intolerable to a man of Dr. Gysi's nature, so to pass the time he started a study and classification of diatomes. He isolated over 2,000 different forms of diatomes; then he arranged them in elaborate patterns so that, when viewed under a high-powered microscope, they became beautiful pieces of art.

In order that he might arrange these diatomes under the microscope into the various artistic patterns, it was necessary that he have an instrument with an exceptionally fine point. For this purpose, he plucked a hair from the inside of his nose and mounted it on a fine glass rod. The hair was selected from the inside of the nose because that is the only place on the human body where the hair grows naturally to a sharp point.

Another interest was what Dr. Gysi called "a slow-motion picture of sound," where a series of pendulums of different lengths were attached to the top of a large table. Each pendulum was equipped with an adjustable weight so that the rapidity of the swing could be controlled. Each pendulum was tuned by adjusting the weight to swing or vibrate in a direct ratio to the number of sound wave vibrations for a definite note. Each pendulum was attached to a stylus which recorded the combined movements in a series of fantastic diagrams.

Dr. Gysi was a man of many interests, and although he devoted much time to what might be termed his hobbies, dentistry was his first and last love. This devotion to the science of dentistry has been recognized by dental associations throughout the world. The American Dental Association made a special citation to him in 1955. He has been the Permanent Honorary President of the Academy of Denture Prosthetics in recognition of his stimulus to that organization. Dr. Gysi was recognized officially throughout Europe on many different occasions for his outstanding research.

Every practicing dentist in the modern world has, at some time, utilized some basic fundamental fact or technique developed by Dr. Gysi. Few men have contributed more to the comfort and happiness of mankind.

> "I have lived, and I have run the course which fortune has allotted me, and now my shade shall descend illustrious to the grave."—Vergil, *The Aeneid*

—*I. Lester Furnas*

928 Silverado St.
La Jolla, Calif.

GERIATRICS AND THE DENTURE PATIENT

CHARLES H. JAMIESON, D.D.S.
Detroit, Mich.

THE HEALTH PROBLEMS ASSOCIATED with our aging population are receiving the careful attention of governmental agencies and the medical profession. The inauguration of social security legislation and the retirement plans of industry accelerated planning for the later years of life.

The United States Public Health Service recently announced the opening of a new center at the National Institutes of Health to spur research into the health problems created by our aging population.

Every day in these United States 1,000 persons reach their sixty-fifth birthday. The population in the age group of 65 years or over has quadrupled since the 1950 census. Recent census reports reveal the number of men and women 65 years of age or over at 14,128,000. This figure is 15.9 per cent higher since 1950. It is estimated that there will be more than 20 million people in this group by 1975. At that time, each active dentist will have a potential of 250 patients past the age of 65 years in his practice. The sixty-fifth birthday marks a period of life when many are forced to alter their former mode of living and begin a new phase of existence sometimes referred to as retirement, sometimes as boredom. As age increases, aches and pains and emotional stress also increase. In New York mental hospitals there are 117,000 mental patients, 40,000 of whom are over the age of 65. The dentist can be an important part of the team which can do much to make the later years of life healthier and happier.

VARIANTS IN AGING

Actually, aging begins at conception,[1] but from a practical viewpoint, aging begins at birth. Thereafter, two phases of aging must be considered—the chronologic age and the physiologic age; the first denoting the passage of time, the second, the resultant effect of the passage of time on the functional elements of the body. The rate of aging varies in individuals, and an applicant for social security at the age of 65 years may have mental alertness approximating the age of 50, but a masticating mechanism approximating the age of 75 years.

Bortz,[2] Director of Lankenau Clinic in Philadelphia, says that aging is largely due to a gradual loss of energy resulting in structural and functional changes in the body. The rate of change may be hastened by toxic agents in the body and adverse hereditary influences.

Read before the Academy of Denture Prosthetics, Columbus, Ohio, April 29, 1957.
Received for publication April 29, 1957.

He also states that ". . . factors which bring about exhaustion of body resources . . . may be identified as various illnesses, disorders of function, disease of organs, abnormal mental attitude, prolonged illness, and many other conditions.

"The accumulated load which organs must carry from previous insults, infections, overeating, prolonged exhaustion are measurable factors which are definitely harmful, but can be controlled by hygiene in such a way that the total body reserve may be protected. The individual, then, can continue into the age period that represents his natural endowment."[2]

ORAL CHANGES IN AGING

All oral tissues are affected by the aging process (Table I). The jaws, teeth, mucous membranes, salivary glands, and associated anatomic structures undergo a gradual retrogressive change as the result of a decrease in the metabolic activity of the individual cells. This impairs the function of all tissues and organs and results in atrophic reactions to stress and irritation rather than the stimulating productive reaction typified in youth.

TABLE I. ORAL MANIFESTATIONS OF AGING

Loss of teeth:	Due primarily to degeneration of periodontal structures.
Attrition:	Rate is directly influenced by physical character of the diet.
Oral mucosa:	Loss of elasticity with dryness and atrophy. Tendency to hyperkeratosis.
Gingivae:	Loss of stippling. Satiny or edematous appearance. Keratinized layer thin or absent. Tissue friable and easily injured.
Saliva:	Diminished function of salivary glands with relative or absolute xerostomia due to atrophy of cells lining the intermediate ducts. Xerostomia results in abnormal taste sensations and stomadynia.
Tongue:	Atrophic glossitis, probably due to concurrent B complex vitamin deficiency states.
Lips:	Angular cheilosis is very common and probably related to concurrent vitamin B deficiency and closed bite. Cheilitis and purse-string mouth due to dehydration.

From Massler, Maury, Courtesy of New York J. Den. 26:60, 1956.

One of the most common complaints of the elderly denture patient is traumatic mucosal irritation. Massler[3] states that this is due mainly to the friability of the tissue, caused by dehydration of the mucosa, together with a gradual thinning of the epithelial layer (Table II). Progressing age makes the mucosa susceptible to even minor irritating stress. It loses elasticity and appears shiny and pebbly. A burning sensation of the tongue and lips and abnormal taste, such as salt and sour, are frequently noted, especially in the postmenopausal period. Eighty per cent of women in this period present this complaint, which is also associated with a decrease in salivary flow causing a dry mouth. These conditions may combine to create tenderness which interferes with the wearing of any removable denture.

TABLE II. DENTAL PROBLEMS IN THE AGED

Tissue friability:	Due to thin atrophic epithelial covering with diminished resistance of the underlying connective tissue. Evidenced as a tendency to painful traumatic ulcers and recurrent aphthae after mild stress or minor irritations. Angular cheilosis probably related to riboflavin deficiency.
Abnormal taste sensations and stomadynia:	Burning sensations in the tongue, persistent, sour or metallic taste, and atrophic glossitis. Probably related to concurrent vitamin B complex and estrogen deficiencies. Often relieved by high vitamin B intake plus increased intake of meat proteins.
Postmenopausal osteoporosis:	Evidenced early in vertebrae. May be related to excessive alveolar ridge resorption.
Excessive bone resorption:	Excessive or rapid vertical or horizontal alveolar bone resorption leading to periodontal diseases. Rapid and excessive ridge resorption under full dentures. Relation to negative calcium balance is suggested.
Delayed wound healing:	Postextraction wound healing often delayed with tendency to intercurrent infections. Often prevented by vitamin C therapy (200 mg. per day before and after surgery). Also related to protein deficiency states. Careful preparation for surgery is mandatory in the aged.
Fungal infections:	Overgrowth of *Candida albicans* common, especially under full dentures, and on tongue.
Vague fears and pains:	Causalgic pain in edentulous area from which a painful tooth was extracted years ago; common and characteristic of the aged. Often related to emotional disturbances. Characteristic of the insecure at any age level. Exaggerated in the aged. Rx: Patience, understanding, and empathy.

From Massler, Maury, Courtesy of New York. J. Den. 26:62, 1956.

The atrophy of oral structures in aging is progressive, and the gradual change in the supporting bone induces the closing of jaw relations, strained temporomandibular structures, and shifting of the denture bases on their foundations. The early loss of posterior teeth without replacement, and dependence upon the anterior teeth for function during the advancing years, is found quite commonly. The maxillary teeth are usually the first to be lost, and a breakdown of the anterior maxillary ridge is the consequence, when it is opposed by natural anterior mandibular teeth in premature contact.

HYPERPLASIA

One of the vexing problems in diagnosis for the gerodontic denture patient is whether or not to remove hyperplastic tissue of the ridges and peripheral structures. If roentgenographic and visual evidence does not demand the removal of the flabby anterior ridge, it is my practice to avoid its excision if the loss of retention of the upper denture would result. Some ridge even though mobile is usually better than no ridge. The static position of this mobile ridge must be maintained in impression making if continuing resorption is to be minimized.

If folds of hyperplastic tissue, caused by border overextension, are present in the buccal or labial vestibules, and if they interfere with the routine seating of the denture base, they should be removed surgically. The border of the old denture should be corrected, and the denture should be worn during healing to prevent

the unfavorable reattachment of the mucosa. If folds occur on the crest of the ridges due to excessive resorption of the underlying bone, surgery is usually advisable to remove not only the mobile tissue, but also the bone spicules which may be continuing sources of discomfort.

Hyperplasia of the palate is frequently found under ill-fitting dentures which lack palatal contact. This type is often nodular in appearance, and if contact is re-established with a well-fitting denture, this hypertrophy may diminish. Surgery is rarely necessary.

PSYCHOLOGIC ASPECTS OF AGING

Fitting the personality of the aged patient is often more difficult than fitting the denture to the mouth. The vague pains and annoyances common to many patients are exaggerated in the aged. The mental quirks and character deficiencies associated with senility are road blocks for the prosthodontist. Patience and understanding are necessary in the treatment of the patient whom we too frequently dismiss as being neurotic.

Elderly people develop fixed habits and ideas and do not adapt readily to change in their mode of life. They tend to endure increasing physical discomfort rather than make the effort to see a doctor for the early treatment of an ailment which may become serious.

Those who have worn dentures for a long time and who have gradually become accustomed to juggling dentures which have outlived their usefulness may object to an increased vertical dimension and the close adaptation of corrective dentures. As senescence progresses, neuromuscular coordination is decreased, often as the result of cerebral accidents of varying degrees. This disturbance of normal function gives rise to difficulties in chewing, swallowing, and speaking. The insertion of dentures which are intended to correct acquired malrelations of the jaws and oral structures are an added source of annoyance. An evaluation of the ability of the patient to accept major improvements in function determines how far we can go toward the ultimate in correction. The transition may require a longer period of adjustment and training for the older patients.

NUTRITION AND AGING

In geriatrics, two important factors influence the health of senior citizens. They are nutrition and exhaustion. There is a definite relationship between impaired masticatory function and general nutritive failure. There is a definite correlation between what and how a man eats and how long he lives. Stieglitz,[4] President of the Academy of Geriatrics, said, "We are what we are today because of our yesterdays."

The definition of an adult as a person who has stopped growing except in the middle is quite accurate in today's whirl of living. Poor nutrition in the older group is one of the most common causes of boredom and loss of interest in daily living. Obesity is frequently the result of poor nutrition and a prime factor affecting longevity. A sound nutritional program will do much to maintain the physical vitality and nervous stability of the older patient. Old people require

less fat and more protein. The older the individual, the more protein per kilogram of body weight is required. For optimum nutrition 1.4 Gm. of protein per kilogram of body weight is necessary. There is never any damage to the health of older persons from too much protein, but if there is inadequate protein, excessive nitrogen loss occurs. Loss of weight follows with mental depression and fatigue accompanied by a decreased resistance to infection and functional disorders.

The minerals are of particular importance to the aged, especially calcium, since calcium loss contributes to bone fragility. A negative calcium balance is often found in the aged when rapid ridge resorption is noted, even though the prosthesis may be functional. Osteoporosis, frequently found in the elderly patient, is the result of calcium deficiency, and a delayed healing of fractures is quite common. The formative bone cells, the osteoblasts, are affected in the aged, and bone becomes brittle because of decreased vascularity, lowered metabolism, and lessened ability to repair. In the dental roentgenograms, this is evident in the resorption of the alveolar crest and the thinning and disappearance of the lamina dura. Bone marrow becomes harder, denser, and whiter, and contains more fat than in a younger person. All mineral requirements are increased in the aged.

In a study of the menus of 27 typical homes for the aged in Pennsylvania, one of the most common deficiences was that of vitamin C. Its importance in maintaining healthy oral tissues is recognized by every dentist. Therapeutic doses of ascorbic acid and vitamin B complex given before and after surgery lessens postoperative swelling, pain, and infection.

It is now well established that exercise and restriction of calories are important factors in delaying senescence. Women can maintain their weight on a daily caloric intake of 1,500 calories or less, and men can do this on 2,000 calories. The caloric intake should be reduced 5 to 7 per cent for each decade past the age of 25 years. If, at the age of 25 years, a moderately active man maintains his weight with 3,000 calories daily, at the age of 65 he should reduce this to 2,400 calories, and at the age of 75 to 2,300 calories. Since protein is not stored in the body it needs to be ingested daily. Fat is stored in the body and more slowly digested, and with age the amount of it should be decreased.

Many older persons develop fixed eating habits and frequently exclude all solids from their menus because of missing teeth or ill-fitting dentures. Low tolerance to biting stress presents difficulties for the denture patient, and he is tempted either to swallow larger and coarser food masses, or to select softer foods which require no mastication. A "tea and toast" diet results in widespread malnutrition when meat, vegetables, and dairy products are not included in the daily food supply.

Sometimes this is because of food costs, since many retired persons feel compelled to live on reduced budgets. They consider meat, fruit, and vegetables as expensive and economize by eating more carbohydrates which are cheaper and easier to prepare. This is indeed false economy, for many of the cheaper cuts of meat are as nutritious as the more costly cuts. There is a saying that "death enters through the mouth." We might also say that life and health and well-being also enter through the mouth.

Dr. Edward L. Bortz* urged medical students (and dental students could well be included) to take greater interest in older patients and to concentrate on the control of diet and reduction of physical and mental stress. He warned against apathy as a major curse of old age.

CONCLUSION

In treating the geriatric denture patient, one must differentiate between the complaints based on deficient tissue tolerance and those due to mental and emotional stimuli. The many extraneous social influences conspire to make the aged feel unwanted and therefore unhappy. Patience and kindness are often the secrets of success with the geriatric denture patient. The prosthodontist needs to be a gerontophile, one who has a special fondness for old people.

REFERENCES

1. Ryan, Edward J.: The Dental Problems of Senescence, J. Pros. Den. **1**:64-70, 1951.
2. Bortz, Edward L.: Stress and Aging, Geriatrics, **10**:93-99, 1955.
3. Massler, Maury: Geriatrics and Gerodontics, New York J. Den. **26**:54-63, 1956.
4. Stieglitz, E. J.: Aging as a Problem of Nutrition, Nut. News, 1949.

563 David Whitney Bldg.
Detroit 26, Mich.

*Ninth Annual Conference on Aging at the University of Michigan.

THE RUBBER BASE IMPRESSION MATERIALS

O. M. Dresen, D.D.S.*

Milwaukee, Wis.

Impression making is a controversial subject; but, if the fundamentals of tissue conditions and ridge form are considered and if the procedure is planned and then executed to fit the individual patient, the controversial aspects of making impressions will be readily resolved. There is no one definite procedure or technique that will fit all patients or all mouth conditions. However, the basic fundamental principles can be applied generally, and the techniques and materials and their manipulation can be adapted to comply with the individual requirements of the case in question within the limits of ability and skill of the dentist.

To be able to make adequate impressions, the dentist must know and recognize the anatomic landmarks of the mouth and understand its minute and gross anatomy. Each dentist usually has a routine technique which he uses with modifications. He should be able to vary this technique and to adapt it to comply with the limitations of the mouth and tissue conditions of each patient. He should use the material or materials that will conform to the conditions presented by any patient and to the limitations so imposed.

CLASSIFICATION OF IMPRESSION PROCEDURES

There are two classes of impression procedures to be considered: (1) the open mouth technique, and (2) the closed mouth technique. In either of these classes, we must consider the *degree* of pressure applied: (1) positive, (2) modified, or (3) negative, and the effect of this pressure on the basal seat area upon which the resulting denture will rest. The dentist should be able to control the amount of pressure applied and to recognize overextension or too much pressure from an examination of the seating area of the resulting impression. In the open mouth technique, the amount of pressure applied is under the control of the dentist. In the closed mouth technique, the pressure is controlled by the patient who may have a varying sense of what constitutes a light pressure or a heavy biting pressure. The comfort of the resulting denture will be affected conversely in direct proportion to the amount of pressure applied when the impression is made, and to the resulting flat spots in the impression where the soft tissues are displaced by the tray.

Tissues that are in a chronic state of distortion because of ill-fitting dentures should be permitted to return to normal before impressions are made; the dentures should be worn as little as possible—or not at all—during this conditioning period.

Read before the Academy of Denture Prosthetics, Columbus, Ohio, May 3, 1957.
Received for publication May 3, 1957.
*Dean, Marquette University, School of Dentistry.

It is never advisable to begin impression procedures for patients who have used adhesive powder or paste until such a period of time, without the use of the adhesive, has elapsed that will permit the tissues to be as nearly normal as possible when the impressions are made.

RUBBER BASE IMPRESSIONS FOR DENTURES

This is the report of a study of the rubber base impression materials and their application to complete and partial denture impressions. For the purpose of this study, one impression material was used for all impressions, and the patients were accepted as they presented themselves in a limited *denture* practice. This would indicate that, for the most part, the mouth and ridge conditions were considerably less favorable than those of patients seeking denture service in a general practice. I have used the rubber base impression materials for over two years, but only during the past year have I concentrated on the use of one material and maintained records of each patient so that data could be supplied on a comprehensive basis. During the first year or year and a half of their use, all of the known materials on the market were used with varying results. Some were discontinued after a short period of use; others were used for a longer period of time. None was entirely unsatisfactory, although some were more difficult to use and control than others. The main fault with many was the extremely rapid rate of flow under very light pressure. This frequently resulted in soreness on the crest of the lower ridge. Some of the patients were not good denture risks because their previous denture experience had raised the question in their minds as to their ability to wear dentures successfully. Sometimes this situation in the mind of the patient is developed by the dentist and his ability to cope with, and resolve, a difficult situation. Dentures were constructed for all of these patients in the order of their presentation, and the same technique was used for all patients. It should be noted that the success or failure of these dentures could be due also to numerous other factors besides the impressions. Psychologic and functional factors influence the success of dentures. The care and confidence of the patient, the ability of the dentist, the preparation of the materials, the recognition of the factors involved in centric relation, vertical dimension, esthetics, balanced occlusion, function, comfort, and patient education influence the effectiveness of the resulting dentures. These factors must all be recognized as an integral part of this study and, no doubt, in some instances, they did influence the end results which were, for the most part, satisfactory and, in some instances, gratifying.

EXTENT OF STUDY

During the past year, only one material* was used in this study, in order to obtain data that would be constant as far as the material itself was concerned. I am fully aware that the results for any patient were influenced by mouth conditions, the ability and limitations of the dentist, technical procedures, judgment, the pain threshold of the patient, and many other factors within and beyond the control of the dentist.

*Neo-Plex, The Surgident Co.

This is a report of the clinical results of the use of the rubber base impression materials on: (1) one hundred lower dentures (upper and lower involved), (2) fifty lower relines (to upper dentures), (3) ten upper dentures (single), and (4) ten partial dentures.

In the case of the complete upper and lower dentures, a modified modeling compound plaster wash impression was used for the upper impressions. This is my choice of upper impression procedures. The rubber base impression material was used for lower impressions only.

THE IMPRESSION TRAYS

The technique was similar for all patients. An overextended modeling compound impression of the mandibular denture area was made. A cast was made in stone, and, when it was fairly dry, the undercuts were blocked out with wax. Additional relief was provided over hard areas and over sharp and spinous ridges. One thickness of baseplate wax was placed over the entire ridge area for a spacer. An oversized and overextended tray was made of quick-curing acrylic resin tray material, and a small upright handle was placed on the anterior ridge area of the tray. The handle serves two purposes: (1) to manipulate the tray in and out of the mouth without having to touch the impression borders, and (2) to aid in positioning the tongue while the impression is in the mouth. The tray was trimmed so as to be short of all soft tissue attachments at its borders and to permit the free movement of the tongue and to cover the mandibular pad posteriorly. The tray was tried in the mouth to verify the computation made in trimming the borders to the cast. The borders and the tissue side of the tray were coated with an adhesive cement to retain the rubber base impression material in the tray. No perforations were made in the lower tray as the material should be confined, though it is permitted to flow toward the borders of the impression.

THE IMPRESSION PROCEDURE

The impression material was carefully measured into a small plastic mixing bowl and spatulated for one and a half minutes so that the two component materials comprising the mix were thoroughly incorporated into each other. The mixed material was placed in the tray. (The material used in this study can be molded with the fingers as it is not tacky or sticky.) The setting time permitted the molding of the material in the tray and the distributing of it to cover the borders and to place it wherever desired. The loaded tray was then carefully and slowly seated in the mouth, using a minimum of pressure to seat the tray easily and comfortably. The patient had been instructed previously to place the tongue anteriorly to contact the lingual side of the handle of the tray and to maintain it in that position. The buccal and labial tissues were molded into place, and the tray was very carefully held in position *with a minimum of pressure for a period of six minutes.* A timer was used in order to judge the time accurately. The impression was removed carefully and examined closely for defects or "flat spots" on the impression of the ridgecrest which would indicate pressure. A sharp explorer was used to gauge the thickness of the material over the hard areas and over the crest of the ridge. The

ideal thickness of material is 3 or 4 mm., with more thickness in areas where the tray was relieved for undercuts or hard areas. The impression, if satisfactory, was poured immediately, using a fairly heavy, smooth mix of stone.

RESULTS

Of one hundred complete lower dentures (occluding with complete upper dentures), made by using the same rubber base impression material and the same technique, regardless of ridge conditions, the following results are reported: (1) fifteen of the dentures required no adjustments; (2) sixty had two or less adjustments; (3) fifteen had more than two and less than four adjustments, and of these fifteen cases, eight were relined and made comfortable; and (4) two upper and lower dentures were remade.

RELINE IMPRESSIONS

A closed mouth technique was used for lower reline impressions. The tissue side of the denture was relieved, and the impression was made in the rubber base material under very light occlusal contact. In fifty lower relines of dentures other than those reported above, forty-seven were comfortable. Three were not sufficiently improved, and new dentures were made subsequently to replace them.

UPPER IMPRESSIONS

Only ten upper impressions were made in the rubber base impression material in an oversized acrylic resin tray. Six holes in the median palatal area of the tray were made with a No. 10 bur to permit the impression material to flow more evenly over the base area. These upper impressions resulted in comfortable dentures with satisfactory retention and stability. However, I prefer a modeling compound plaster wash upper impression and use it for most patients, but I use the rubber base impression materials in an oversized acrylic resin tray for impressions for immediate dentures.

Preliminary impressions are made in an alginate material in a stock tray and an oversized acrylic resin tray is made over the cast formed in this impression. The final impression is made in the rubber base material in the oversized acrylic resin tray. This technique is used also for partial denture impressions.

CONCLUSIONS

The rubber base impression materials provide accurate impressions of edentulous ridges, particularly for lower dentures. They fulfill the requirements of an impression material in that comfortable, stable, and functional dentures can be constructed, provided all other technical procedures are correctly carried out. These procedures include the establishment of centric relation, interdental space, balanced occlusion, equalized pressure, and all of the other factors so necessary to successful dentures. The impression material must be handled carefully in order to attain satisfactory results, but so must any material. The setting time of no less than five minutes in the mouth is of importance. The cast should be poured into

the impression immediately after its removal from the mouth. If reasonable care is exercised in the use of the rubber base impression materials, comfortable dentures requiring very few adjustments will result—providing all other factors are equally well observed in their use and application.

This is a practical clinical report of our experience and observations in the use of a rubber base impression material and its application to varying mouth conditions. It is not intended to be a report on a technical procedure or on the accuracy of the material itself.

I wish to acknowledge the research done by Gunnar Ryge[1] on the "Elastic Properties of Rubber Base Impression Materials" which provided the scientific background for these practical clinical applications of these materials.

REFERENCE

1. Fairhurst, C. W., Furman, T. C., Schallhorn, R. V., Kirkpatrick, E. L., and Ryge, G.: Elastic Properties of Rubber Base Impression Materials, J. Pros. Den. **6**:534-542, 1956.

735 North Water St.
Milwaukee 3, Wis.

FRENOPLASTY

JOHN H. LEE, DIP.D.S., L.D.S., R.C.S. (ENG.),*
AND DAVID DOWNTON, F.D.S., R.C.S. (ENG.)**
Eastman Dental Hospital, London, England

THE LABIAL AND BUCCAL FRENULA are frequently associated with the problem of developing and maintaining adequate retention in complete upper and lower dentures. This is due primarily to the nature of the dense fibrous strand of tissue present in the frenula. It has not the elastic property of the adjacent connective tissue and is, therefore, unsuitable for producing the required elastic strain necessary to prevent the effect of atmospheric pressure from operating on the inner (impression) surface of the denture.

These frenula have been called muscle attachments by some authorities, but after dissecting a number of them we believe they consist of a strand of fibrous tissue, covered with mucous membrane, extending from the soft tissue of the lip or cheek to an attachment on the alveolar process.

In those cases where it has been considered advisable to remove these frenula, the following technique has been used successfully.

SURGICAL REMOVAL OF THE FRENUM

The lip or cheek is pulled out so that the frenum is taut. The underlying fibrous tissue strand can then be seen stretched and extending from the soft tissue of the lip to the alveolar process (Fig. 1).

Vertical incisions are made through the mucous membrane on each side of the fibrous strand down to, but not penetrating, the periosteum and leaving mucous membrane flaps on each side (Fig. 2,*A*).

A third incision is made connecting the first two incisions at the alveolar process below the point of attachment (Fig. 2,*B*). The fibrous strand is then dissected out and a further V-shaped incision is made to separate the base of the frenum from the lip or cheek, as the case may be (Fig. 2,*C*).

The first or "anchor" suture is inserted at the level of the junction of the mucous membrane and the mucoperiosteum of the alveolar process. The needle is passed through one mucous membrane flap, then under the periosteum, and finally through the mucous membrane flap of the opposite side (Fig. 3). This ensures that the two mucous membrane flaps are firmly held to the periosteum

Received for publication May 7, 1957.

*Senior Lecturer, The Department of Prosthetic Dentistry, Institute of Dental Surgery, London.

**Assistant Lecturer, The Department of Oral Surgery, Institute of Dental Surgery, London, and Consultant at the Royal Free Hospital, London.

at the height of the vestibular sulcus. Further suturing of the soft tissue of the lip or cheek is then carried out as necessary (Fig. 4).

If the patient has a denture, it may be lined with zinc oxide and eugenol paste and inserted, as it will help to keep the damaged tissue at rest and promote rapid healing (Fig. 5).

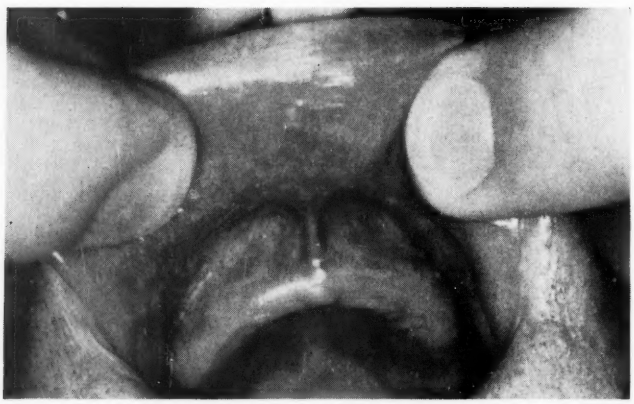


Fig. 1.—A labial frenum attaching low on the residual ridge.

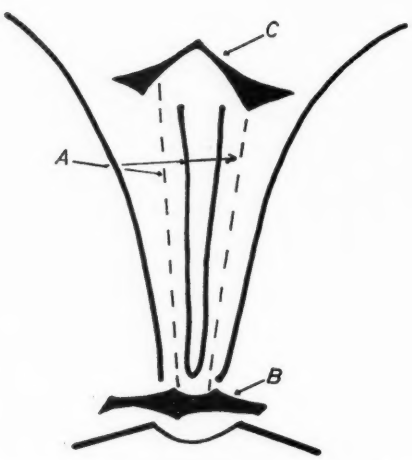


Fig. 2.—The incisions for removing the frenum. *A*, The vertical incisions. *B*, The lower horizontal incision. *C*, The incision to separate the frenum from the lip or cheek.

Fig. 3.—The "anchor" suture.

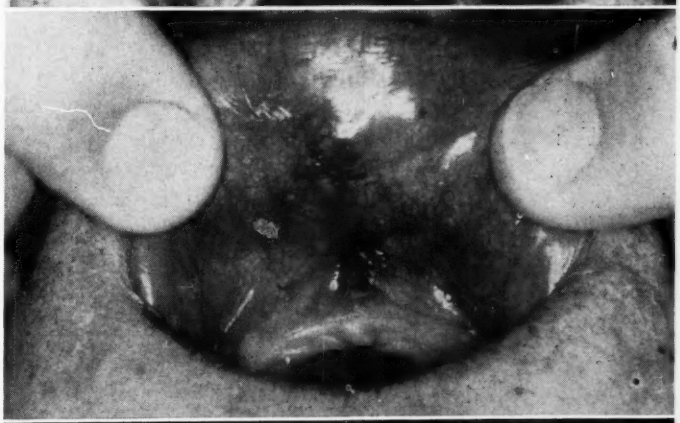


Fig. 4.—The suturing is completed.

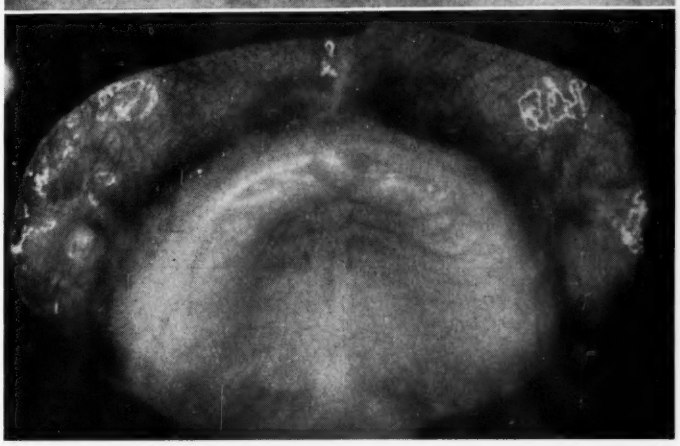


Fig. 5.—The anterior part of the ridge after healing is complete.

Frenula up to 1.0 cm. in width have been removed very satisfactorily with this technique, but care must be taken so that the periosteum is not penetrated by the incisions, and so that the "anchor" suture is in the correct position. No attempt should be made to suture the mucoperiosteal part of the incision.

Eastman Dental Hospital
Gray's Inn Road
London, W.C.I., England

REPOSITIONING OF THE SUBLINGUAL FOLD FOR COMPLETE DENTURES

E. T. Lewis, D.D.S.
Pittsburgh, Pa.

Many of the problems that arise during the course of denture construction can be solved easily through a knowledge of anatomy and anatomic landmarks. We must utilize this knowledge to our advantage. A most important area for retention of the lower denture is the anterior lingual region, from cuspid to cuspid. We must examine this area thoroughly and, according to its character, learn to evaluate the mandible and the floor of the mouth as to the ease or difficulty which will be encountered in constructing a denture for it.

Many failures in lower denture construction are caused by having no definite plan of boundary outlines. In order for a dentist to understand a difficult lower denture foundation, he must be able to differentiate between simple and difficult conditions and to recognize the conditions that cause failures, and he must be able to correct these conditions. All of the difficult mandibular denture foundations can be simplified with surgery.

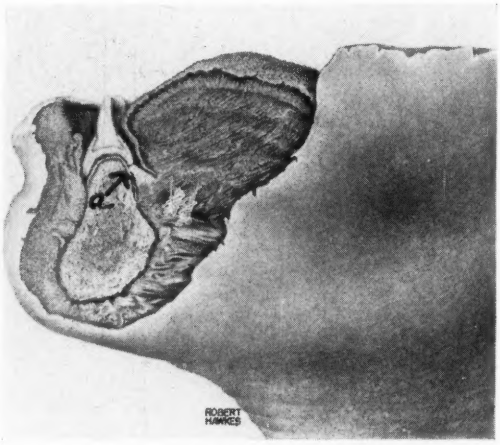


Fig. 1.—Diagram showing the denture in place and the tongue in a functional position. Note that there is no sublingual fold space *(a)* to seal the denture properly.

I have used many techniques and all the resources at my disposal for the correction of the anterior lingual region.[1] In those patients with a congenital absence of space in the sublingual fold, and in those patients for whom the dentist

Received for publication April 15, 1957.

has failed to provide a sublingual fold space at the time he extracted the teeth, it must be created surgically. It is impossible to provide a lower denture with maximum stability until the anterior lingual area has been prepared surgically to form space in the sublingual fold. In my early experience, approximately 80 per cent of the 120 patients treated maintained the space in the sublingual fold

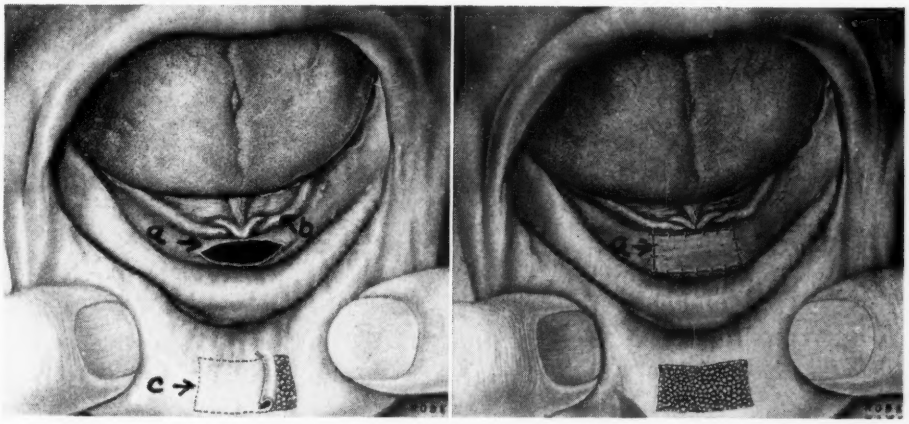


Fig. 2.—The incision (*a*) permits the sublingual fold (*b*) to fall back and create the sublingual fold space. The mucous membrane graft is outlined and is being dissected from the lip (*c*).

Fig. 3.—The mucous membrane graft is sutured in place (*a*). This creates the sublingual fold space

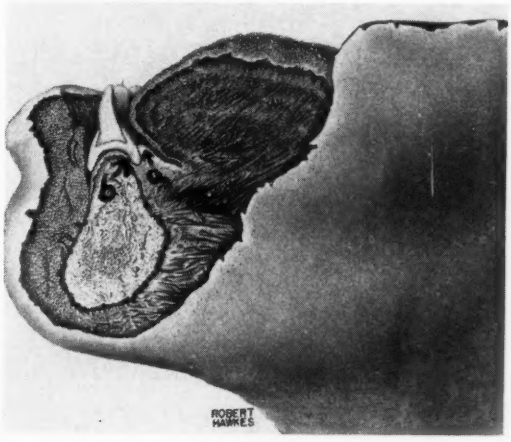


Fig. 4.—The denture is in place. Note the relation of the lingual flange to the sublingual fold *(a)* and to the sublingual fold space *(b)*.

that I had developed by various surgical techniques. However, due to the fact that the degree of scar formation varies with patients, 20 per cent of those surgically treated remained difficult to handle, and some had to be corrected surgically a second time. The failures were due to the amount of shrinkage that took place in the patients having a tendency toward scar formation. The higher the degree

of scar formation, the greater the shrinkage. Therefore, adequate space in the sublingual fold could not be maintained if the patient had a tendency toward scar formation.

CONTROL OF SHRINKAGE OF SCAR

In an effort to control the shrinkage, grafts of skin into the fold were considered. These were not satisfactory due to the difference between the texture of the skin and that of the mucous membrane. An eye surgeon, Dr. I. J. Morgan, suggested that I use a graft of mucous membrane from the lip. The technique is similar to that used in eye surgery.

I have made fifty-four mucous membrane grafts from the lip to the anterior lingual area on patients, and I no longer get shrinkage from the scar tissue. With this procedure, I can maintain the sublingual fold and the space which I obtain in the surgery.

SURGICAL TECHNIQUE

The following technique is suggested for obtaining the necessary space in the sublingual fold.

1. Make an incision in the mucous membrane on the lingual side of the mandible, about 2 mm. in front of the submaxillary caruncles (Fig. 1,*a*), and extend it from the region of one cuspid to the other. This is a very important step. The greatest care must be exercised when this incision is made in order to develop the proper height of the sublingual fold and proper width of the space in it.

2. Measure the width and length of the area that the labial mucous membrane is to cover (Fig. 2,*a*). This is done by using an instrument or by sight.

3. Place two sutures attached to a hemostat (one on each side of the lip) in such a way as to hold the lip down.

4. With a scalpel make a rectangular outline of the proper size in the mucous membrane of the lip. Place a suture at one end of the circumscribed membrane. This suture will be used to transfer this membrane to its new site.

5. Dissect this rectangular-shaped mucous membrane section from the lip (Fig. 2,*c*). Place the graft in normal saline solution immediately.

6. Suture the mucous membrane graft in place in the sublingual fold (Fig. 3).

7. Suture a roll of sterile gauze in place over the graft. The sutures are placed at three points on the ridge, and at four points on the sublingual fold. The roll of gauze will protect the graft until it is healed. Then the gauze is removed.

SUMMARY

Mouths without sufficient space in the sublingual fold doom dentures to failure, despite the skill of the dentist. Unless the dentist becomes familiar with, and understands, the techniques for surgical preparations of these mouths, he will have difficulty in establishing accurate and usable denture borders. The floor of

the mouth on the lingual side of the ridge is extremely movable in function. A mucous membrane graft placed in this area makes the problems much simpler (Fig. 4). If a lower denture is constructed with adhesion, horizontal stability, and a completely functional border, it will not require much time to instruct the patient in its use, and the struggle by the patient to control the dentures during function will be eliminated.

REFERENCE

1. Lewis, E. T.: The Genial Tubercle Space in Full Lower Dentures, J. Pros. Den. **4**:606-610, 1954.

Suite 5112, Jenkins Arcade
Pittsburgh 22, Pa.

PREPARATION OF CASTS FOR IMMEDIATE DENTURES

STANLEY G. STANDARD, D.D.S.

New York, N. Y.

IMMEDIATE DENTURE SERVICE SHOULD be a routine procedure in dental practice. Much has been written to impress upon dentists the many advantages of this treatment plan. In the past decade, patients have become aware of its value and have insisted that such service be rendered.

The greatest appeal to patients is the fact that they may have teeth replaced without the embarrassment of an edentulous period. Patients are impressed also by the fact that, when some anterior teeth are present, the dentist is in a better position to select artificial teeth that will simulate the natural teeth as to color, size, shape, and position in the arch more accurately. Another important advantage, which is more readily appreciated by the dentist than the patient, is the ability to control ridge form by a properly fitted immediate denture. The stimulation to the tissues supporting an accurately fitted immediate denture is conducive to their rapid healing with a minimum of bone resorption.

My clinical observations indicate that there is regeneration of bone and development of the ridge area to the contours of a properly adapted immediate denture. To accomplish this successfully, there must be complete tissue coverage by the immediate denture, with adequately defined borders. The elimination of the labial plate of the alveolar bone, the butting of the anterior teeth to the ridges, or even a partial restoration of the labial flange of the denture will tend to result in the loss of this important role of ridge control. Such measures are used only because of a fear of an abnormal protrusion of the upper lip.

I will describe a method whereby the polished surface of the labial flange of the upper denture can be placed in the same position as was the original surface of the mucosa. Thus, the normal fullness of the upper lip without protrusion will be retained. In this position, the flange supplies the original support for the orbicularis oris muscle. The normal tonus of this muscle is maintained, and the personality and lip contour of the patient will be retained.

IMPRESSIONS

An exact record of the shape of the tissues to be covered by the denture base must be obtained. The best results are obtained by the use of an elastic impression material in an oversized plastic tray. The tray is trimmed short of reflecting border tissues. The borders of the tray are determined by the use of

Read before the Academy of Denture Prosthetics, Columbus, Ohio, April 29, 1957.
Received for publication April 29, 1957.

modeling compound or wax. The impression is completed with one of the alginate or rubber base impression materials (Fig. 1).

The usual recordings of vertical dimension and centric relation are obtained. The posterior teeth are set in occlusion and checked in the mouth. When the jaw relations and occlusion are found to be correct, the trial dentures are returned to the cast on the articulator. Porcelain or plastic anterior teeth of the same size and mold are selected to be arranged in the same relationship that existed between the natural teeth which they replace.

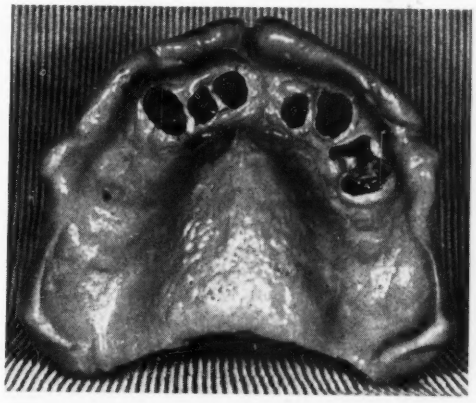


Fig. 1.—An alginate impression in a spaced plastic tray.

Fig. 2.

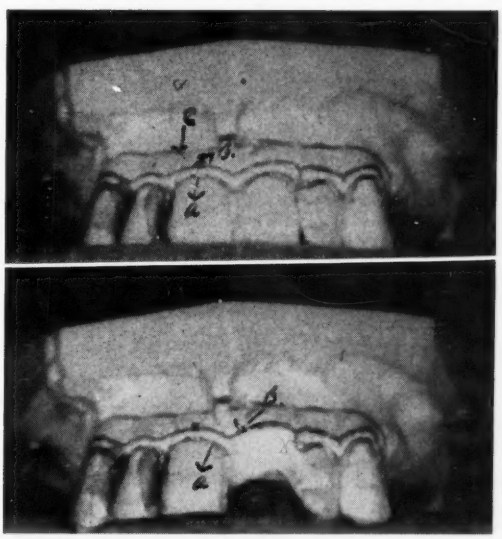


Fig. 3.

Fig. 2.—The cast is outlined. *A*, The gingival line. *B*, The line 2 mm. above and parallel to the gingival line. *C*, The line marking the beginning of the undercut area.

Fig. 3.—The first tooth is cut off, and the cast is trimmed to line *B* and bevelled 2 mm. toward the lingual gingival line.

OUTLINING THE CAST

The gingival margins of all teeth on the cast are outlined in pencil on both the labial and lingual sides. Another pencil line is drawn on the labial surface of the cast exactly 2 mm. above this gingival line and parallel to it. A third pencil line is placed on the labial surface of the cast at the beginning of the undercut area (Fig. 2).

Fig. 4.

Fig. 5.

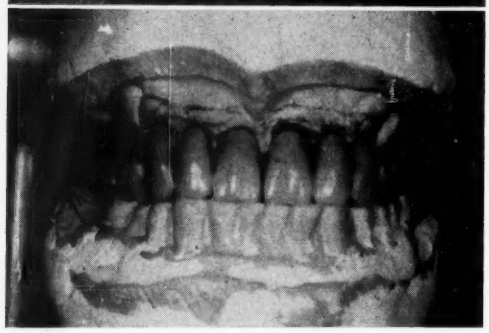


Fig. 4.—Alternate teeth are cut off the cast, and the artificial replacements are fitted and luted to the wax trial base.

Fig. 5.—The remaining artificial teeth are ground into position and luted to the base.

PREPARING THE CAST

The first stone tooth is cut off at the gingival pencil line with a plaster saw. With a sharp knife or a small tapered stone, the cast is cut down to the second pencil line, which is 2 mm. above the gingival line. The stone cast is cut back to a depth of 2 mm., and the stone is bevelled from the depth of this cut to the lingual pencil line (Fig. 3). The artificial tooth is ground to fit this space and set in the same position as that occupied by the stone tooth.

The remaining stone teeth are cut off of the cast alternately, one at a time (Fig. 4), and the corresponding artificial teeth are shaped by grinding and secured to the wax trial base (Fig. 5).

The wax trial base (Fig. 6) is removed, and the cast is prepared for the labial flange. The stone is scraped from the third pencil line (representing the

beginning of the undercut area on the labial surface of the cast) to the lingual gingival line, until a well-rounded, smooth ridge is established (Fig. 7).

The wax trial base, with all the teeth firmly luted to it, is replaced on the prepared cast, and the labial flange is waxed up (Fig. 8).

This method of cast preparation permits the insertion of the completed denture with a minimum of bone surgery. The labial flange of the denture will be 2 mm. or less in thickness. The upper lip should rest against the teeth and the

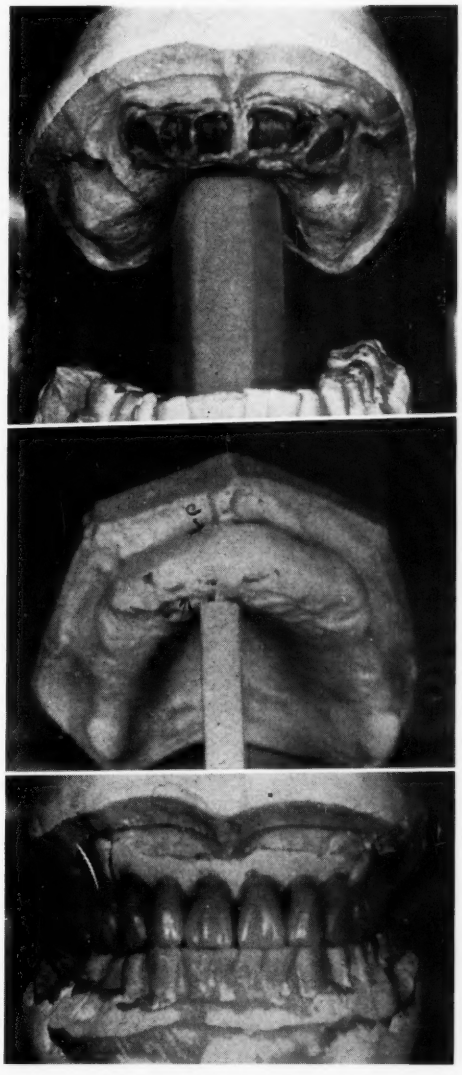


Fig. 6.

Fig. 7.

Fig. 8.

Fig. 6.—The trial base is removed from the cast. Note the appearance of the cast where the teeth have been removed.

Fig. 7.—The cast is prepared by trimming, from the lingual gingival line *A* to *C*, the line marking the beginning of the undercut. This trimming eliminates the seats made for the artificial teeth.

Fig. 8.—The wax trial base is returned to the cast for wax-up of the labial flange.

polished surface of the denture, in the same position as it did against the natural teeth and mucosa. Experience has shown that resorption is reduced to a minimum. The normal expression and profile of the patient are retained.

SUMMARY

1. A method of preparing a cast for an immediate denture has been described.
2. A measured amount of the stone cast is removed and replaced with the same amount of denture base material.
3. The normal expression and lip contour of the patient are retained.

225 West 34th Street
New York 1, N. Y.

VERTICAL DIMENSION AND CENTRIC JAW RELATION IN COMPLETE DENTURE CONSTRUCTION

EARLE S. SMITH, D.D.S.*
State University of Iowa, College of Dentistry, Iowa City, Iowa

ONE OF THE IMPORTANT RECORDS preparatory to mounting casts on an instrument for the construction of complete upper and lower dentures is the centric jaw relation record. The vertical dimension record is at least of equal importance. Centric jaw relation has been defined as "the most retruded relation of the mandible to the maxillae when the condyles are in the most posterior unstrained position in the glenoid fossae from which lateral movement can be made, at any given degree of jaw separation."[1] This statement is inexact. The anteroposterior and lateral relationship between the mandible and the maxillae for a given individual can be recorded at varying degrees of jaw separation. However, a recording at other than the correct vertical dimension is not the true centric jaw relation for this individual. Centric jaw relation is three-dimensional, and the vertical dimension should be considered as one of these three dimensions.

VERTICAL DIMENSION

The vertical dimension of the face at the physiologic rest position should be such that the elevator and the depressor muscles attached to the mandible are in equilibrium in tonic centric contraction. At this vertical dimension, the condyles occupy a neutral unstrained position beneath the anterior part of the glenoid fossae. This is the position of the condyles in relation to the glenoid fossae which is considered as normal when movements of mastication are initiated.

A vertical dimension greater or a vertical dimension less than the correct vertical dimension of occlusion will be accompanied by adverse results. If it is greater than the correct vertical dimension of occlusion, the muscles of closure will be under constant strain, there will be no free-way space (interocclusal distance), and excessive resorption of the residual ridges will take place. The patient will experience difficulty when he opens his mouth sufficiently wide for the incision of food, and he will experience constant discomfort, a discomfort he will find hard to analyze as to location and cause.

If the vertical dimension is less than the correct vertical dimension of occlusion, the muscles of closure will not be extended to their full capacity. This in turn will result in loss of muscle tone and efficiency. Folds and wrinkles will develop, and the patient will become disturbed about his facial appearance.

Since so much concerning the comfort, efficiency, and esthetics of the patient depends on the vertical dimension of the centric jaw relationship record, careful work in its estimation is essential. Also, since the other two dimensions involved in centric jaw relation are dependent on the vertical dimension, the determination of

Read before the Academy of Denture Prosthetics, Columbus, Ohio, April 29, 1957.
Received for publication April 29, 1957.
*Professor Emeritus, Clinical Prosthetic Dentistry.

the vertical dimension logically has precedence in the technical sequences to be followed.

Accuracy in establishing patient jaw relations may be obliterated by an overly complicated routine. Therefore, it seems appropriate that the mention of some simple procedures may have interest and value.

Thompson[2] has stated, "The vertical dimension associated with 'sinking-in' of the lips is greater than the occlusal vertical dimension made before the teeth were extracted. The facial change is not the result of a decrease in vertical dimension, but rather of the loss of support given the lips by the teeth and alveolar processes."

Proper lip support being a prerequisite if accurate measurements are to be made, the maxillary occlusion rim should be so formed on its labial aspect that it gives the desired support. The location of the plane of orientation should then be established.

ESTABLISHING PLANE OF ORIENTATION

The height of the occlusal plane anteriorly should be in harmony with the type of lip. Rather than to follow a set rule for establishing the anterior segment of this plane slightly below the border of the relaxed upper lip, as is so often recommended, the plane of orientation should be above and hidden if the lip is long and flexible, or it should be below and plainly in view if the lip is short, tight, and tense. It is only for those patients who have lips of average length that the plane of orientation should be slightly below the relaxed upper lip.

From the frontal aspect, the plane of orientation should be horizontal. It may not be parallel with a line through the pupils of the eyes, as this line is not always horizontal. The plane of orientation should be parallel with the floor as the patient stands erect. An estimation of this parallelism can be made easily by observation while the dentist stands at arms' length in front of the patient and stretches the corners of the patient's mouth.

The approximate height of the plane posteriorly can be estimated by placing the tip of one's index finger over the mandibular ridge anteriorly and having the patient close upon it. Then, while the mandible is thus held in a position of approximate centric relation, the imaginary plane can be projected posteriorly. If the plane is properly located, it will intersect the retromolar pad at or near its base.

Based upon the conclusions reached from the observations made, the location of the plane of orientation (plane of occlusion) on the maxillary trial base can be established.

ESTABLISHING VERTICAL DIMENSION FOR CENTRIC RELATION

It would be valuable if there were some simple mechanical device by which the vertical dimension for the centric jaw relation could be determined. The nearest approach to such a device is the Boos Bimeter. However, its use is somewhat difficult and several adverse variables may be involved.

A routine of making vertical measurements between two small marks on the face is quite often followed in attempting to determine the rest vertical dimension. One mark is placed just below the nose and the other is placed over the tip of the chin. Measurements are made between the marks while the facial muscles are

relaxed. The occluding vertical dimension is computed by subtracting 3 mm. from the measurement obtained between the two marks at the rest position.

Complete relaxation of the muscles of mastication is necessary when making the measurements. In fact, complete relaxation of the body as a whole is desirable. Conditioning exercises as suggested by Boos[3] can be highly recommended. The patient practices opening and closing the mouth and moving the mandible from side to side and backward and forward several times a day for a period of several days before denture construction is instituted. The use of hot packs and mild sedation as suggested by Block[4] may be necessary to attain complete relaxation.

There are various routines which may be followed in attempting to get the mandible into the desired position when making the measurements. Among these are:

1. The patient is instructed to open his mouth widely, then to relax his jaw and close it to a position of rest. The lips may, or may not, come into contact. (Some patients are mouth breathers.)
2. The patient is instructed to close his mouth after he has held it open for a period of time sufficient to create tiredness of the involved musculature.
3. Phonetic tests, such as the pronunciation of "m," "Iowa," or "Ohio," may be used.
4. The patient is asked to balance a drop or two of water in the mouth without swallowing. This is accomplished at the physiologic rest position. He then swallows the water and the jaw assumes the occluding position.
5. The strained or unstrained facial appearance of the patient may be used as a guide. None of these routines is without fault, and much depends upon the judgment of the dentist.

Because of the importance of the development of the correct amount of interarch space in determining the vertical dimension desired for the centric jaw relation, the routine followed *should not be complicated.*

With this in mind, a mandibular trial base with an abbreviated wax occlusion rim extending from lateral incisor to lateral incisor or cuspid to cuspid is used to develop the correct amount of interarch space. The maxillary and mandibular occlusion rims contact in a limited area when placed in the mouth and brought into occlusion. Vertical dimension alone is to be considered at this time. The simple procedures of increasing or reducing the height of the mandibular occlusion rim and the remeasuring of the distance between the marks on the face are carried out until the vertical dimesion desired has been attained.

When the correct degree of interarch separation has been determined by the contact anteriorly, the mandibular occlusion rim is ready for completion posteriorly. Wax that can be made quite soft and that will set reasonably hard is added to the lower rim posteriorly from the abbreviated anterior segment. The wax is added in slight excess to the areas on both sides of the mandibular rim. These masses of wax are then softened uniformly, and the occlusion rims are reinserted in the patient's mouth. The patient is directed to relax the jaw muscles and to close until the occlusion rims contact anteriorly. Tests are then made to determine whether the opposing rims come into uniform contact. If they do not, corrections are made.

Once uniformity of contact has been accomplished, Shanahan's method[5] for determining physiologic vertical dimension will be found helpful in verifying the accuracy of the vertical dimension determined by the method just described. Three small balls of soft wax are placed on the occlusal surface of the mandibular occlusion rim. One is placed at the midline and one in the region of the bicuspids on each side of the occlusion rim. The balls of wax are subjected to closing pressures during repeated swallowing movements, and the degree to which they become flattened is the criterion.

THE CENTRIC RELATION RECORD

When the vertical dimension of the centric jaw relation of an individual has been established, but not until then, it becomes logical to incorporate the anteroposterior and the lateral dimensions of this relation.

The method to be followed depends on the preference of the dentist. Arrow point tracings are used by some, and occlusion rims brought into occluding contact are used by others. Whichever method is followed, the objectives are to find the most retruded position of the mandible in relation to the maxillae when the condyles are in their most posterior unstrained positions in the glenoid fossae from which lateral movements can be made and to record *this relationship at the specific vertical dimension of occlusion selected as being normal for this particular individual.* It is logical to consider that this is a recording of the centric jaw relation for this individual and that recordings made at other degrees of jaw separation are not the true centric relation.

Even though the condyles were in correct anatomic position for centric jaw relation when the interarch relationship was recorded, the distance from and the relationship to the condylar axis of the patient were not included in this record. This orientation is desirable if the casts are to be properly positioned on the articulator. The relationship of the jaws to the condylar axis, anteroposteriorly, laterally, and vertically, can be determined and transferred to the articulator by means of a face-bow. It seems outside of the province of this article to discuss the face-bow other than to recommend its use at some stage in the mounting of the casts on the articulator.

CONCLUSION

An accurate centric jaw relationship record is important when constructing dentures. It is a three-dimenisonal record and, to be accurate for a given individual, the relationship, anteroposteriorly and laterally, should be recorded at the occlusal vertical dimension deemed correct for this individual. A recording made at other than the correct vertical dimension of occlusion is not a true centric jaw relation record.

REFERENCES

1. Glossary of Prosthodontic Terms, J. Pros. Den. **6**:11, 1956.
2. Thompson, John R.: The Rest Position of the Mandible and Its Significance to Dental Science, J.A.D.A. **33**:151, 1946.
3. Boos, Ralph H.: Physiologic Denture Technique, J. Pros. Den. **6**:726-740, 1956.
4. Block, L. S.: Tensions and Intermaxillary Relations, J. Pros. Den. **4**:204-207, 1954.
5. Shanahan, Thomas E. J.: Physiologic Vertical Dimension and Centric Relation, J. Pros. Den. **6**:741-747, 1956.

State University of Iowa
College of Dentistry
Iowa City, Iowa

HINGE AXIS REGISTRATION: EXPERIMENTS ON THE ARTICULATOR

OLLE BORGH, L.D.S.,* AND ULF POSSELT, L.D.S., ODONT. DR.**
The Royal Dental School, Malmö, Sweden

SOME AUTHORS[1, 2, 4] HOLD THAT the hinge axis of the mandible can be located with extreme accuracy with the aid of a kinematic face-bow. Others[3] maintain that not even on the articulator is the actual opening angle[5, 6] of 10 to 15 degrees large enough to secure an exact location of the hinge axis.

It seems logical that if axis points[5] cannot be exactly reproduced in a series of records on an articulator, where the intercondylar axis can be secured in the centers of the condylar mechanisms, it is probable that the difficulty will be considerably greater in the patient. We considered it worthwhile checking the results obtained by Kurth and Feinstein,[3] because a great number of authors, especially those belonging to the McCollum school, consider the individual location of the hinge axis of great importance for further work on the articulator.

However, the tests presented here aim only at elucidating part of the problem, because the determination of the variability of the axis points in experiments on the articulator cannot solve the clinical problem of hinge axis recording by the face-bow. This can be checked only by means of recordings on patients.

MATERIAL AND METHODS

A Hanau Model H articulator, modified by one of us (P), was used for these registrations (Fig. 1). The shaft of the articulator was replaced by one with pointed ends pointing at millimeter square-ruled plates mounted on the articulator (Figs. 1 and 2). The plates were equipped with frames into which specially adjusted celluloid plates were fastened. The registration points are marked as recorded by the face-bow on these celluloid plates. Parallax errors were eliminated by carefully placing the celluloid plate flat against the square-ruled plate.

The incisal guide was replaced by a horizontal brass plate, from which the magnitude of opening could be determined by means of a wooden wedge (Fig. 3). In order to standardize the magnitude of opening, two wooden wedges were used, one corresponding to 10 degrees and the other to 15 degrees of opening.

In order to avoid any influence by earlier results when making a series of registrations, the registration plate was covered by black paper (Fig. 4). Thus, any influence of the gradation of the millimeter square-ruling on the examiner was

Reprinted and revised from the Odontologisk Revy, 7:214-220, 1956; courtesy of Dr. R. Helmer, editor.
Received for publication Nov. 21, 1956.
*Demonstrator, the Department of Occlusal Analysis and Rehabilitation.
**Head of the Department of Occlusal Analysis and Rehabilitation.

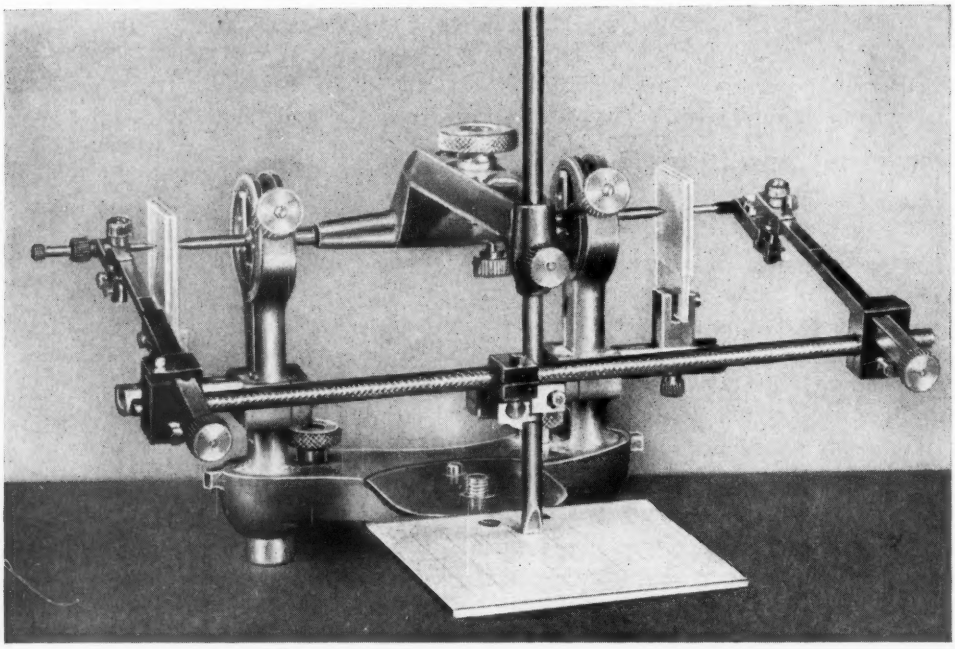


Fig. 1.—The modified Hanau articulator with the Hanau adjustable hinge axis face-bow attached.

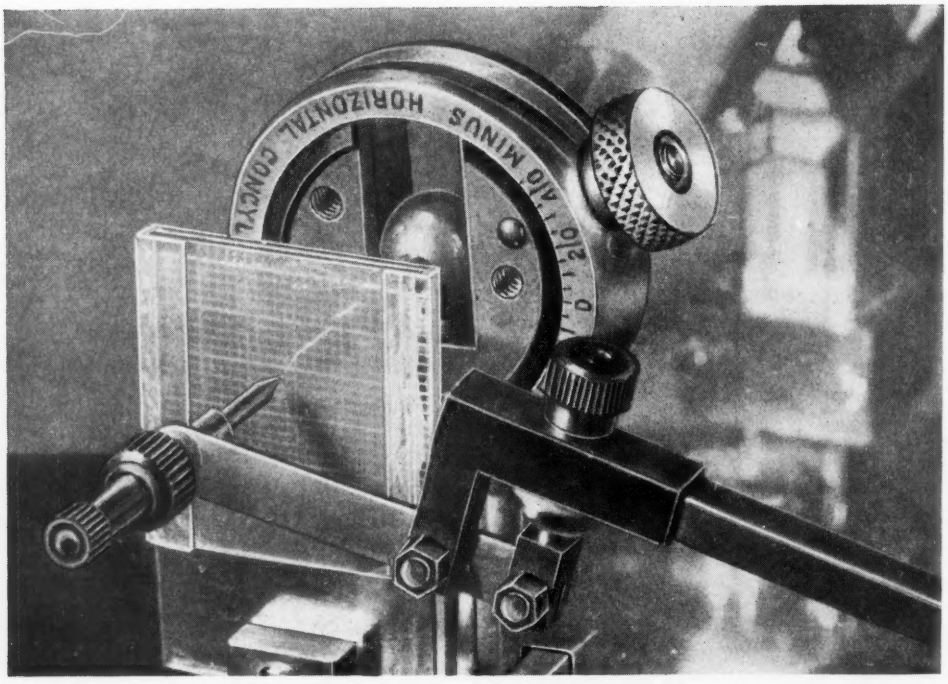


Fig. 2.—The condylar pointer and the millimeter square-ruled measuring plate.

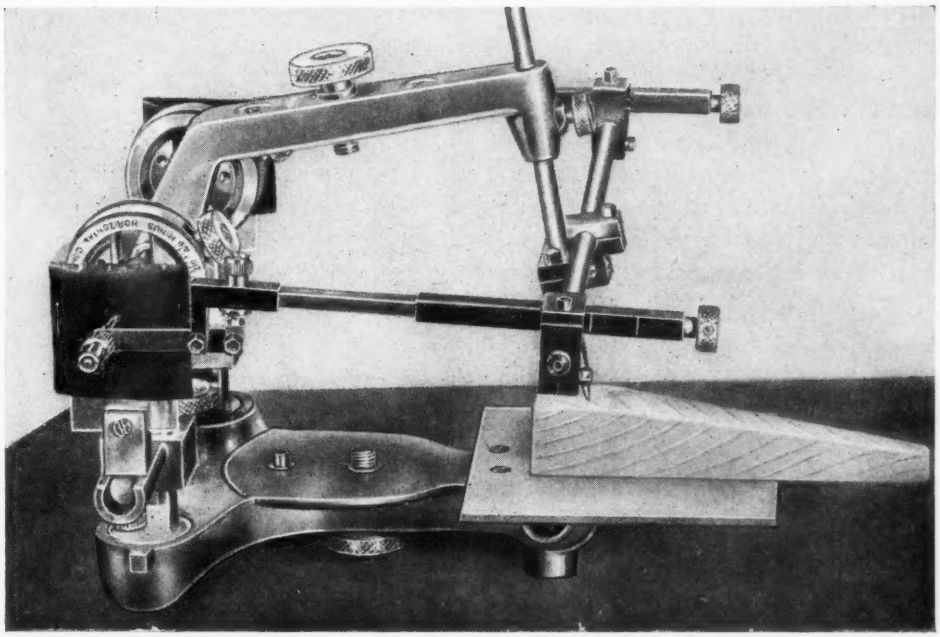


Fig. 3.—A side view of the articulator, the incisal pin of which rests on one of the wooden wedges.

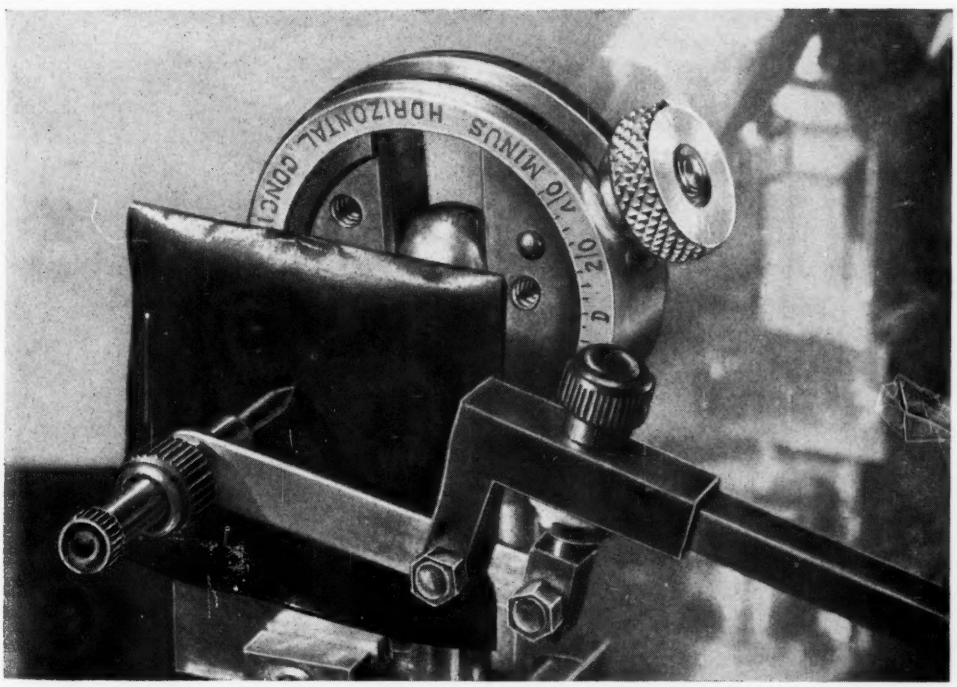


Fig. 4.—The black paper envelope covering the measuring plate.

avoided, and the ends of the articulator shaft were concealed. A Hanau adjustable hinge axis face-bow was attached to the articulator.

The inclination of the condylar paths was fixed at 90 degrees so that the articulator shaft remained in zero position during the registrations.

The experiments were carried out by one of us (B). They fall into three series: (1) ten double-sided registrations with a magnitude of opening of 10 degrees, (2) ten double-sided registrations with a magnitude of opening of 15 degrees, and (3) ten double-sided registrations, each of which was preceded by detachment and remounting of the face-bow to the articulator.

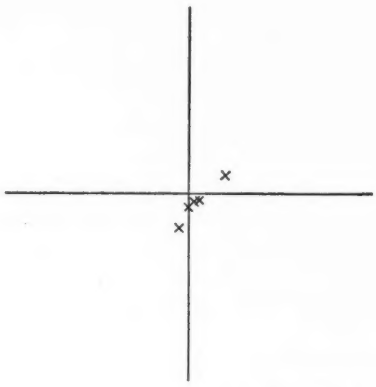


Fig. 5.—Axis points as recorded with 10 degrees of opening of the articulator. Left condylar mechanism. A number of the registrations coincide. (× 5.)

Series I: Ten Degree Opening.—Before the first registration, the zero point of either registration plate was adjusted to the articulator shaft. The registration plates were then covered with black paper. The incisal pin was resting on the horizontal brass plate. The articulator was opened slowly until the incisal pin rested on the upper surface of the wooden wedge (Fig. 3). During this shift, the condylar pointers of the face-bow were carefully observed. When the condylar pointer seemed to perform a pure rotation, the locking device holding each condylar pointer was loosened, and the condylar pointer was brought against the registration plate, where it perforated the black paper as well as the celluloid plate. The condylar pointers were set arbitrarily, and another black-paper coating was attached before the next registration was made.

Series II: Fifteen Degree Opening.—The registrations in this series were performed in exactly the same way as has been described above, with the exception that the higher wooden wedge (corresponding to 15 degree opening) was used.

Series III.—In this series, the face-bow and the upper member of the articulator were detached and mounted again between the various registrations. Ten degree openings as well as 15 degree openings were registered with 5 recordings in each group.

When all registrations in each series had been performed, the registration plates were detached, and the perforations made by the condylar pointers in the celluloid plates were studied in their relationship to the millimeter square-ruled registration

plate. The differences from the zero point had been transferred to the millimeter square-ruled paper.

RESULTS

Some of the results of the registrations are shown in Figs. 5 and 6. In this connection, it is to be noted that a number of registrations coincide in Series I as well as in Series II. The results in Series III are not recorded here, as there were no observable differences between these registrations and those performed earlier.

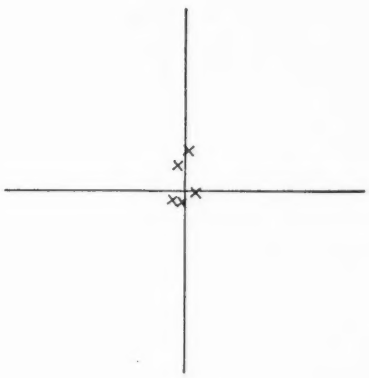


Fig. 6.—Axis points as recorded with 15 degrees of opening of the articulator. Left condylar mechanism. A number of registrations coincide. (× 5.)

DISCUSSION

Kurth and Feinstein,[3] in an opening of the articulator of about 10 degrees, found the centers to lie "in an area of about 2 mm." Provided that the authors mean an area with a diameter of 2 mm., our results show only slightly less variation. Thirty experiments on either side gave diameters not exceeding 1.5 mm. for 10 degree opening, and not exceeding 1 mm. for 15 degree opening.

Still, the location of the axis points cannot be said to be without error or variation for the degree of opening encountered in the patient.

SUMMARY

Registrations of the hinge opening axis were carried out with the aid of a kinematic face-bow mounted on a modified Hanau articulator. Three experimental series were carried out, both with 10 degree and with 15 degree openings, with the following results.

The axis of the hinge movement as carried out on the articulator could not be recorded without error at the above degrees of opening.

The ranges of variation correspond to areas with diameters of 1.0 to 1.5 mm., slightly less with 15 degrees than with 10 degrees of opening. On the whole, the findings corroborate those obtained by Kurth and Feinstein.

REFERENCES

1. Collett, H. A.: The Movements of the Temporomandibular Joint and Their Relation to the Problems of Occlusion, J. Pros. Den. **5**:486-496, 1955.
2. Granger, E. R.: Centric Relation, J. Pros. Den. **2**:160-171, 1952.
3. Kurth, L. E., and Feinstein, I. K.: The Hinge Axis of the Mandible, J. Pros. Den. **1**:327-332, 1951.
4. McCollum, B. B.: Fundamentals Involved in Prescribing Restorative Dental Remedies. D. Items Interest **61**:522-535, 641-648, 724-736, 852-863, 942-950, 1939.
5. Posselt, U.: Terminal Hinge Movement of the Mandible, J. Pros. Den. **7**:787-797, 1957.
6. Ulrich, J.: Undersøgelser over Kjaebeleddet hos Mennesket med saerligt Hensyn til de mekaniske Forhold., Copenhagen, 1896.

The Royal Dental School
Malmö S, Sweden

A CONTRIBUTION TO THE STUDY OF THE MOVEMENTS OF THE MANDIBLE

NORMAN G. BENNETT, M.B., L.D.S.

THE MOVEMENTS OF THE MANDIBLE have been the subject of much investigation during the last few years, and several communications on the subject have been made to this and other societies. The contribution which I propose to place before you this evening is somewhat fragmentary and consists mainly of an account of some experiments which I undertook some time ago, but have not had time to carry out to a full extent. As these experiments, however, were mainly directed to the elucidation of one or two points, which did not appear to me to have been adequately dealt with by other workers, I thought they might be of interest to members of this Section and possibly stimulate further work on similar lines.

I do not propose to discuss in detail former communications on this subject, with most of which you are familiar; but I must briefly refer to the particular aspects of the problem upon which it did not appear to me sufficient light had been shed; and by avoiding the introduction of names I hope to escape from the need of subsequently supporting in the correspondence columns of the dental Press any opinions I may venture to offer, or criticisms of the statements of others which I may be compelled to make, in connection with this thorny problem.

In the first place, it has been shown that the shape and curve of the surface with which the interarticular fibro-cartilage articulates varies considerably in different races and in different individuals of the same race; secondly, that the movement of the mandible does not consist simply of rotation about the condyle; thirdly, that the curves formed by successive positions of the moving condyle or, in brief, the path of the condyle, vary considerably in different individuals, as, indeed, would be expected from an examination of the dry bones.

So far as I know, no correlation between the movement of the condyle and the movement of the chin or symphysis, or indeed between any two points on the jaw, has been ascertained or exhibited. Furthermore, a fixed centre of rotation, outside the condyle, for the ordinary movements of opening and closing, has been supposed to exist, and much discussion—futile discussion, I may venture to call it—has taken place as to its exact position. I shall try to show you that no single fixed centre exists, but that the centre of rotation is constantly shifting. A path may be marked out showing the successive positions of the instantaneous centre of rotation for any given movement of opening or closing, and this path varies with the character of the movement.

In order to discover the exact correlation between simultaneous positions of the condyle and the symphysis in one individual, I made a somewhat elaborate

Reprinted from the Proceedings of the Royal Society of Medicine, Section of Odontology, April 27, 1908, pp. 79-95, by special permission granted to Dr. Joseph S. Landa by the Royal Society of Medicine. This article will serve as background for an article by Dr. Landa entitled "A Critical Analysis of the Bennett Movement" which will be published in subsequent issues of the JOURNAL OF PROSTHETIC DENTISTRY.

apparatus for use in my own case. It so happens that, on account of the loss of lower molar teeth on each side, it was possible to construct a kind of rough metal plate like the bar of a lower denture, to fix firmly to the teeth by means of ordinary bands, and having wire extensions passing behind the premolars and round the buccal surfaces of the canines and incisors and meeting in the median line. By this means I found it possible to obtain quite firm fixation without in any way interfering with normal and complete occlusion. The wire extensions of the pseudo-denture were soldered at the point of meeting and passed outside the mouth with a suitable curve so as to interfere as little as possible with the movements of the lips. To this was attached an outside framework of wire with a side piece in a vertical plane parallel to the median plane and just outside the right condyle. Two very small incandescent glow-lamps were then attached, one immediately opposite the condyle and one opposite the sulcus below the lower lip. Here again I was favored by Nature, because my condyles are thinly covered and can be exactly located with extreme ease, so that there was little difficulty in fixing the lamp with the tiny filament opposite the centre of the condyle. The exact position of the other lamp was of minor importance, because, as I shall presently show, a second lamp in any position is equally satisfactory; the lamps were connected with a small dry battery by means of fine, light insulated wires. The next step was to fix my head so that there should be no movement except that of the mandible. For this purpose I sat in a strong wooden chair having a high back and a kind of projecting wooden canopy with an oval hole cut in it to receive the crown of my head as far as the upper part of the forehead in front and the most prominent part of the occiput behind. I found, however, that to drive my head into this sufficiently hard to be firmly fixed was distinctly unpleasant, and it was necessary to interpose some adaptable material. An old and soft straw hat answered the purpose admirably; and I was then able to sit with all the apparatus fixed, and with my right side opposite to and parallel with a bare wall, in moderate comfort. Between myself and the wall was interposed a biconvex lens arranged on an adjustable stand. A large sheet of paper was pinned to the wall, the room was darkened, and the connection with the battery was made. The lens was brought into focus and the images of the two lamps were plainly seen, upside down of course, on the paper. The magnification depended upon the distance between the lamps and the wall. A convenient adjunct was an ordinary looking-glass placed in front of me at an angle of about 45 degrees, so that I could myself see the lamp images on the wall.

In this way I was enabled to open and shut my mouth slowly or rapidly and in a natural manner and to varying extents. While I did this, my brother marked a series of corresponding points on the paper where the images of the two lamps for the moment rested, and we obtained the large diagrams, I., II., III., which you see hung up. We afterwards obtained the diagram IV., to show lateral movements; for this purpose I, of course, sat facing the wall.

Now it is obvious that as the distance between the lamps is fixed, and is, in fact, 8.8 cm., or 3½ in., the length between the pairs of corresponding points representing the two images should also be constant, and this fact afforded a useful check on the accuracy of the diagrams. We found that, although the magnification was considerable, the variations in this constant were very small; but the charts I., II., III., IV., prepared from the diagrams by means of the pantograph, have been

slightly corrected by this constant; these have been photographed, and I shall presently show them to you on the screen.

I pass on to consider next the whole question of the centre of rotation. I am dealing now with movements of the mandible only in a verticle plane, that is to say, with positions which the mandible can assume without lateral movement. The mandible is, even in this limited respect, still capable of two independent movements, one being an angular rotation about the condyle, and the other being a translational movement (with no angular rotation), produced by the gliding of the condyle in its path. In the execution of any natural movement, it is exceptional to find either of these simple movements alone; they are usually combined. Hence it results that the centre of rotation about which the mandible may be regarded as turning, at any instant, has a position not only different from that of the condyle itself, but capable of considerable variation with the nature of the movement.

As a preliminary to the attempt to follow the shifting centre of rotation during the normal opening movement of the mandible, it may clear the ground if I give a short discussion as to the purely geometrical and mechanical theory of the centre of rotation. I will ask your attention to a small mathematical demonstration.

Let a sheet of paper be supposed to slide about in any manner on a table. Let two points, A B (fig. 1), marked on the paper be used to specify its position. Join A B, and let A′ B′, A″ B″ &c. represent the successive position of A B produced by the sliding of the paper. Join A A′, B B′, and from the middle points of these lines draw perpendiculars until they meet at the point O. Then it is obvious that O A = O A′ and O B = O B′ and, of course, A B = A′ B′. In other words, the two triangles O A B and O A′ B′ are identical, and the movement from A B to A′ B′ may be accomplished by rotating the triangle O A B about the point O as centre. Next join A′ A″ and B′ B″, and in the same way obtain the point O′, and so on with all the succeeding positions. It is clear that the points O, O′, O″, &c. on the table form a series of centres of rotation about which A B moves.

Next from the point O draw O S′ = O O′, and inclined to it at an angle equal to the inclination of A B to A′ B′, that is to say, the angle through which A B moves about O. From S′ draw S″ = O′ O″, and inclined to it at an angle equal to the inclination of A B to A″ B″, and so on to the last position.

We have now obtained two polygons. Now imagine the polygon O S′ S″ to be traced on the paper. Rotate O S′ about O until S′ coincides with O′ and A B with A′ B′; again rotate S′ S″ about O′ until S″ coincides with O″ and A B with A″ B″, and so on; that is to say, the rolling of the one polygon on the other exactly reproduces the changes of position of the paper. In the case we have considered, the various positions of A B are taken at comparatively wide intervals, so that the lines joining the series of centres of rotation form a polygon; but if we imagine them very close together, then it is clear that the polygon will become a continuous curve. We have now arrived at this important truth, namely, that any form of continuous plane motion may be represented, or reproduced by, the rolling of one curve upon another. These curves are called "centrodes," and the successive points of contact are called the "instantaneous centres." The forms of the curves, of course, vary with the character of the movement, but for any particular movement two centrodes, uniquely associated with that movement, may be derived, and the rolling of one centrode on the other will reproduce that movement.

In order to make this quite clear, I have prepared a simple working model belonging to the figure which we have just discussed. It consists actually of two planes, the one sliding on the other. On the moving plane are drawn the line A B and the centrode O S′ &c., forming parts of the edge; and the fixed plane is the

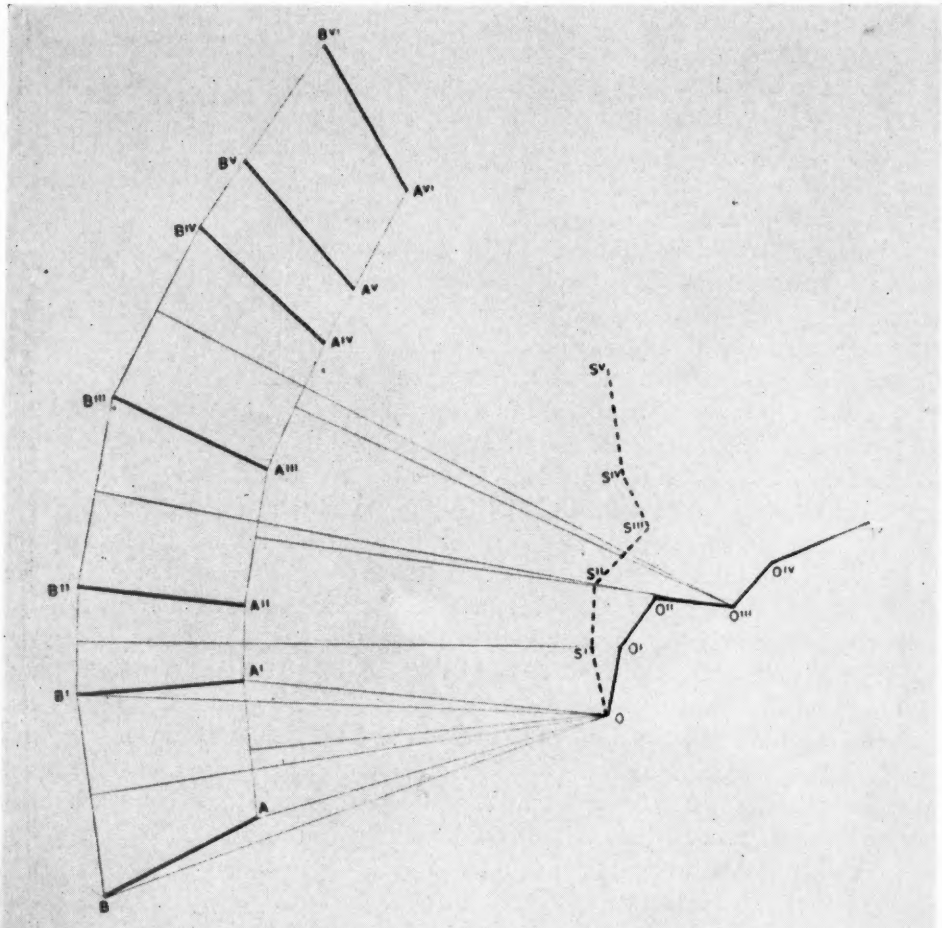


FIG. 1.

A B represent two points on a sheet of paper. A B, A′ B′, &c., represent successive positions of A B produced by the sliding of the sheet of paper on a table. O, O′, O″, &c., marked on the table, represent the series of centres of rotation about which A B turns. The movable polygon, or centrode, O S′ S″, &c., marked on the paper, if rolled on the fixed polygon, or centrode, O O′ O″, &c., will reproduce the several changes of position of A B.

diagram from which the lantern slide was prepared (fig. 1). If you place the moving piece in its lowest position, with the lines A B on each plane coincident, and then move it slowly round to the right so that the two centrodes are always in contact, you will see that when S′ becomes coincident with O′, A B coincides with A′ B′, and so on.

We may now examine the charts derived from actual movements of the mandible. Fig. 2 represents the paths of the condyle and symphysis in normal opening and closing, and the crosses outside the latter path represent extreme forward and backward positions associated with different degrees of opening. The cross lines are numbered and lettered to show the corresponding positions of the two moving points.

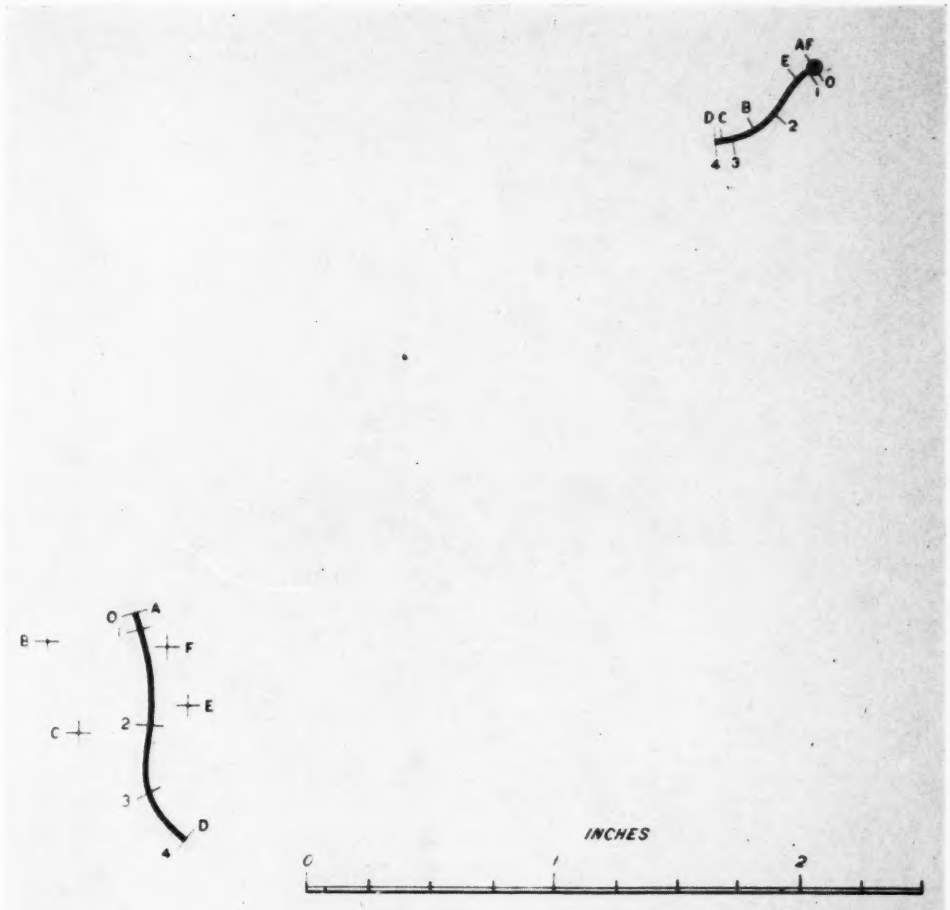


FIG. 2.

The upper curved line represents the path of the condyle and the lower curved line the path of the symphysis during the normal movement of opening and closing. The crosses represent extreme positions of the symphysis. The letters and figures indicate corresponding positions of the condyle and symphysis.

In fig. 3, from the same diagram, are shown the positions of the centres, by rotation about which each position of the mandible may be brought into its next consecutive position.

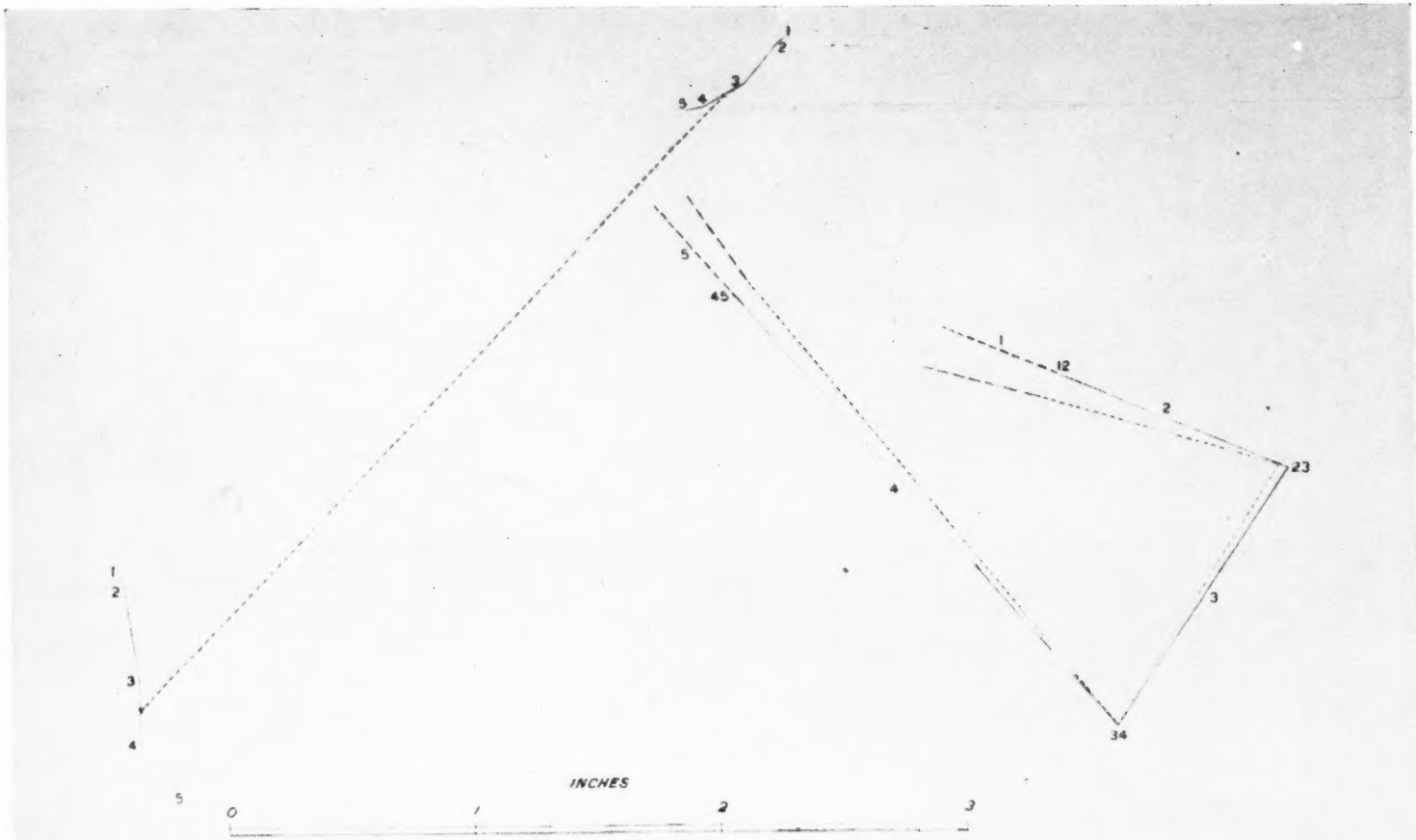


FIG. 3.

The paths of the condyle and symphysis are represented nearly as in fig. 2. The long, straight, interrupted line represents a line joining the condyle and symphysis. The two polygons shown by continuous and interrupted lines represent the fixed and movable centrodes respectively. The figure represents an intermediate position of opening, when the mandible is passing from the point 3 to the point 4, and the movable centrode is rotating about the point 34 on the fixed centrode.

You see here the paths of the condyle and symphysis and also the fixed centrode. The line AB in fig. 1 is in this case, of course, the line joining the two lamps at the condyle and the symphysis.

I will now pass round this working model derived from the chart I have just shown, and you will again see that the rolling of one centrode on the other reproduces the movement of the condyle and symphysis from point to point in the series of momentary positions of rest.

In fig. 4, again derived from the same diagram, you see as before the paths of the condyle and symphysis, but the fixed centrode or path of the series of instantaneous centres is shown as a continuous curve. This has been obtained by making use of the whole curved paths of the condyle and symphysis. In other words, where the polygon shows a series of a definite number of instantaneous centres corresponding to the series of momentary positions of rest of the mandible, and joined by straight lines, the curve shows an infinite number of correlative positions passed through by the condyle and symphysis.

I will now pass round another working model, and you will again see that the rolling of one centrode on the other perfectly reproduces the movements of the condyle and symphysis, or, in point of fact, the model moves exactly as the mandible did in my head and as its movement was shown on the wall. We see, then, quite plainly that there is no one centre of rotation for the mandibular movement, but that the centre is constantly shifting. It starts at a point behind and below the condyle, travels backwards and downwards, then forwards, and finally upwards and forwards, finishing at a point a little below the condyle path.

Fig. 5, from a different observation shows the condyle path on a much larger scale.

In obtaining the diagram from which fig. 6 was derived, the second glow-lamp, instead of being fixed opposite the symphysis, was placed close to the condyle lamp, so as to give a larger magnification than in diagram I. From these two paths centrodes could be drawn which would perfectly reproduce the movement, and if the position of the symphysis were noted with the jaw closed, its movements would follow. In other words, for the purpose of reproducing the movement of the mandible, the paths of the condyle and of any other point are sufficient.

I have now to show you a piece of mechanism designed to exhibit, by means of a simple linkwork, the general characteristics of the movement of the mandible executed in opening and closing the mouth. It shows (fig. 7) the condyle, C, and the symphysis, S, moving on paths of some such shapes and lengths and relative situation as are found to occur in practice. It shows also for every position of the mandible the particular position of the instantaneous centre, I, about which the mandible is at the moment turning. The scale of the mechanism is a little more than 1 ft. to the inch.

Let us now return for a moment to fig. 2, and take note of the correlative positions shown. In the first place it is seen that even for very small openings there is a small forward movement of the condyle, that is to say, simple rotation about the condyle does not occur. In the second place, when the position of extreme opening is nearly reached, the condylar movement is small in comparison with that of the symphysis. In fact, the condylar movement appears to be somewhat the

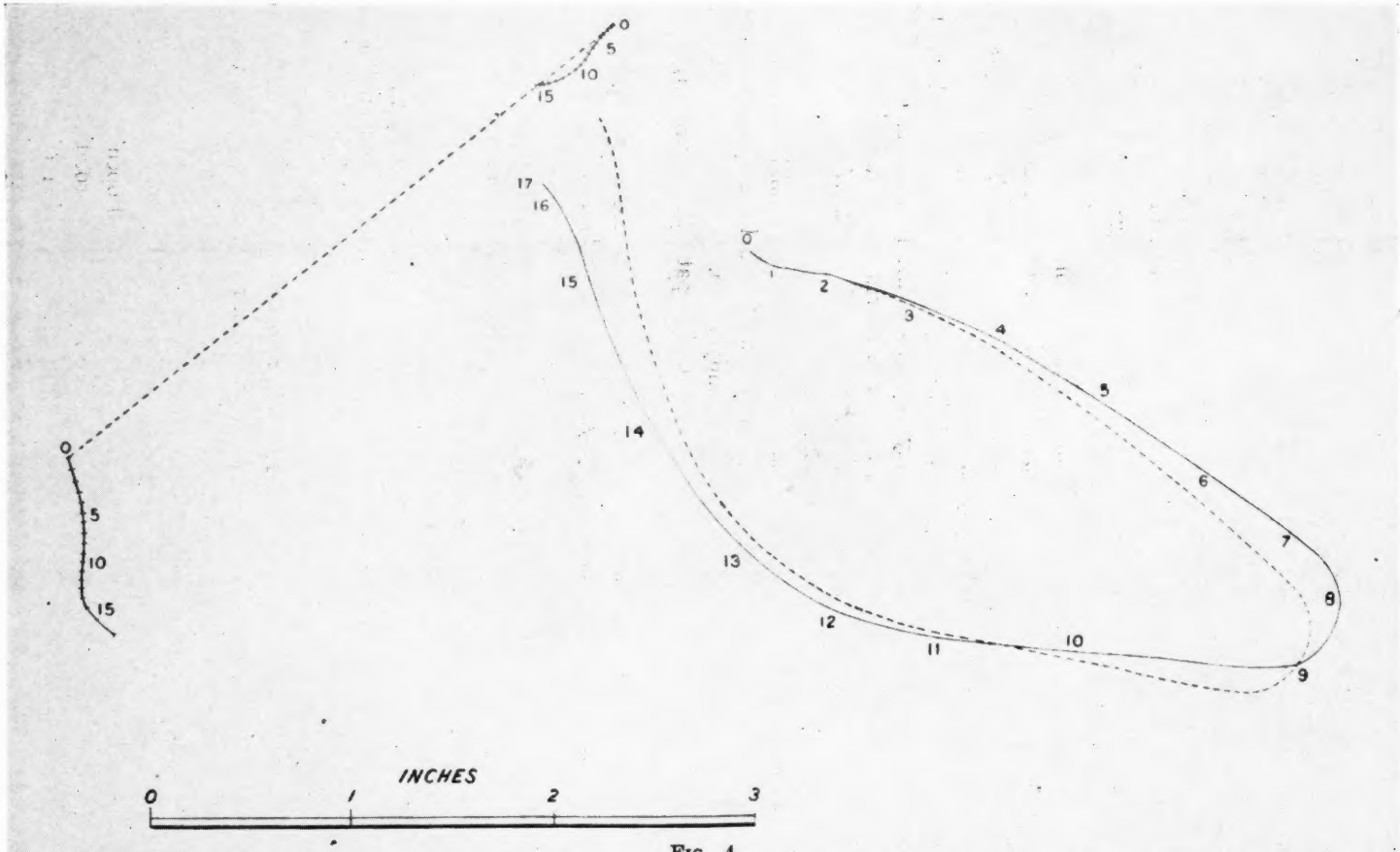


FIG. 4.

The paths of the condyle and symphysis are represented exactly as in fig. 2. The long, straight, interrupted line represents a line joining the condyle and symphysis. The two large curves shown by continuous and interrupted lines represent the fixed and movable centrodes respectively. The figure represents the position of complete occlusion of the mandible. If the movable centrode be imagined to roll on the fixed centrode, the two ends of the long interrupted line will pass through the successive correlative positions on the paths of the condyle and symphysis that correspond to the points of contact of the two centrodes.

greatest, relatively to that of the symphysis, during the intermediate position of moderate opening.

Now the normal position of rest of the mandible is with the teeth slightly separated, but with the lips easily closed. When watching the formation of the curves on the wall during the experiments I took particular note of this position and tried it several times. The first cross mark on each path shows the position of rest, which is a very definite one as judged by subjective sensation; and it is after

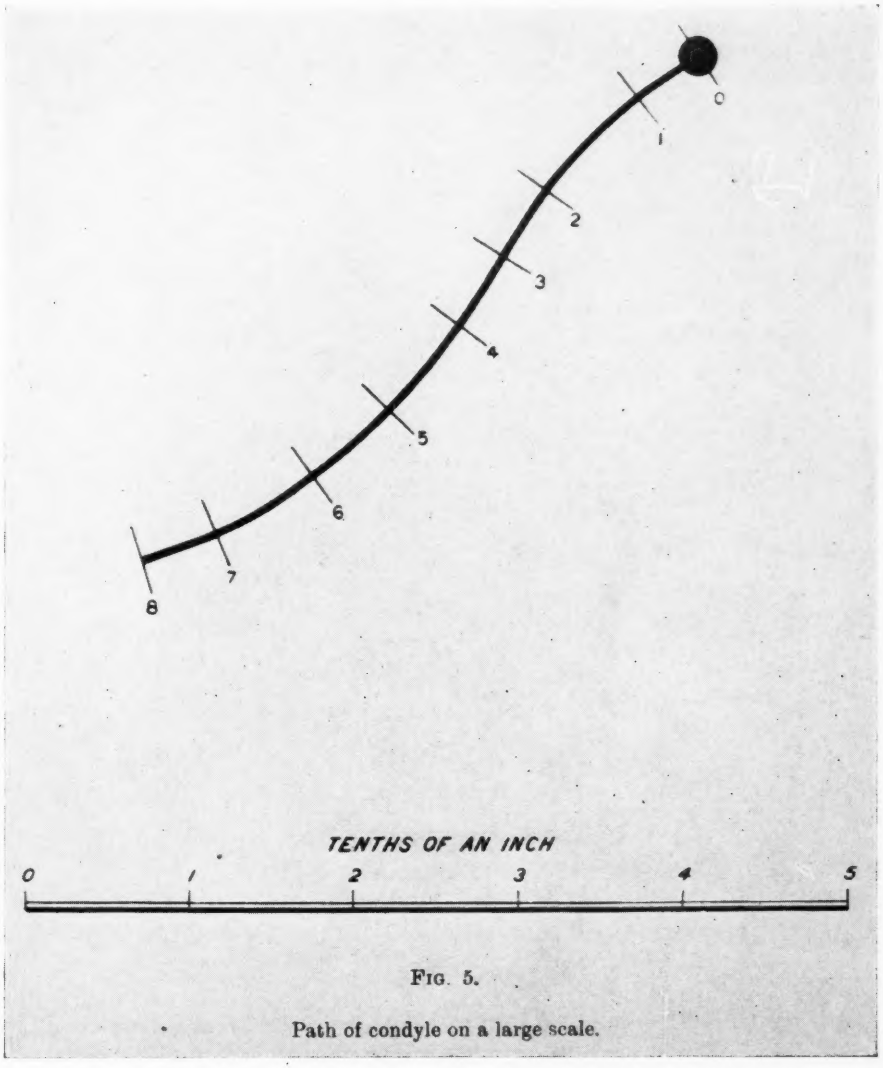


FIG. 5.

Path of condyle on a large scale.

passing this point that the movement of the condyle seems to become rather suddenly considerable, although there is movement of translation from the very commencement, and the initial centre of rotation is, as I pointed out, below and behind the condyle. This fact seems to me to bear distinctly on the question of altering the height of bites in articulators. I mean that if a bite be taken which is found to be

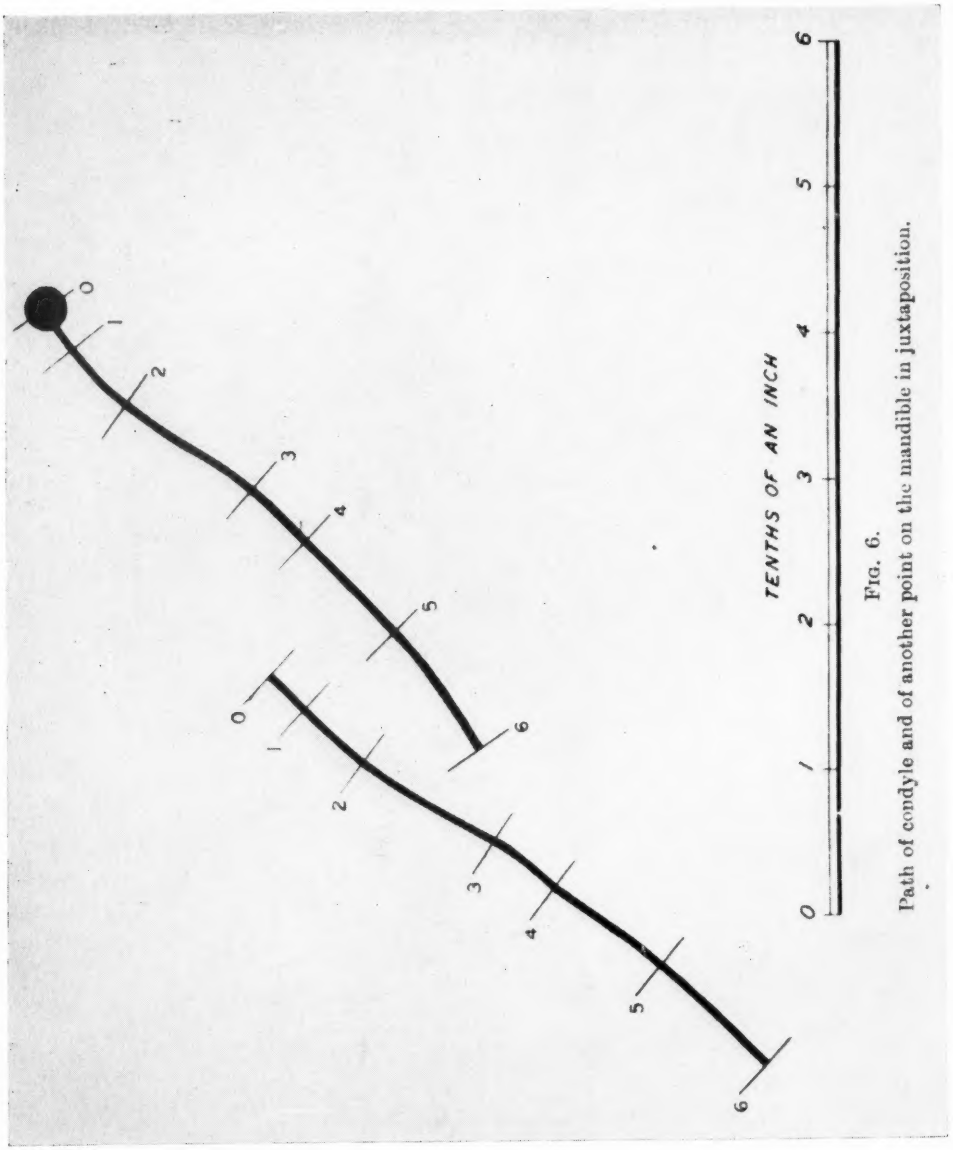


FIG. 6.

Path of condyle and of another point on the mandible in juxtaposition.

too much open and the height is reduced in a hinge articulator with the hinge correctly placed in relation to the plane of occlusion, errors will be introduced and the

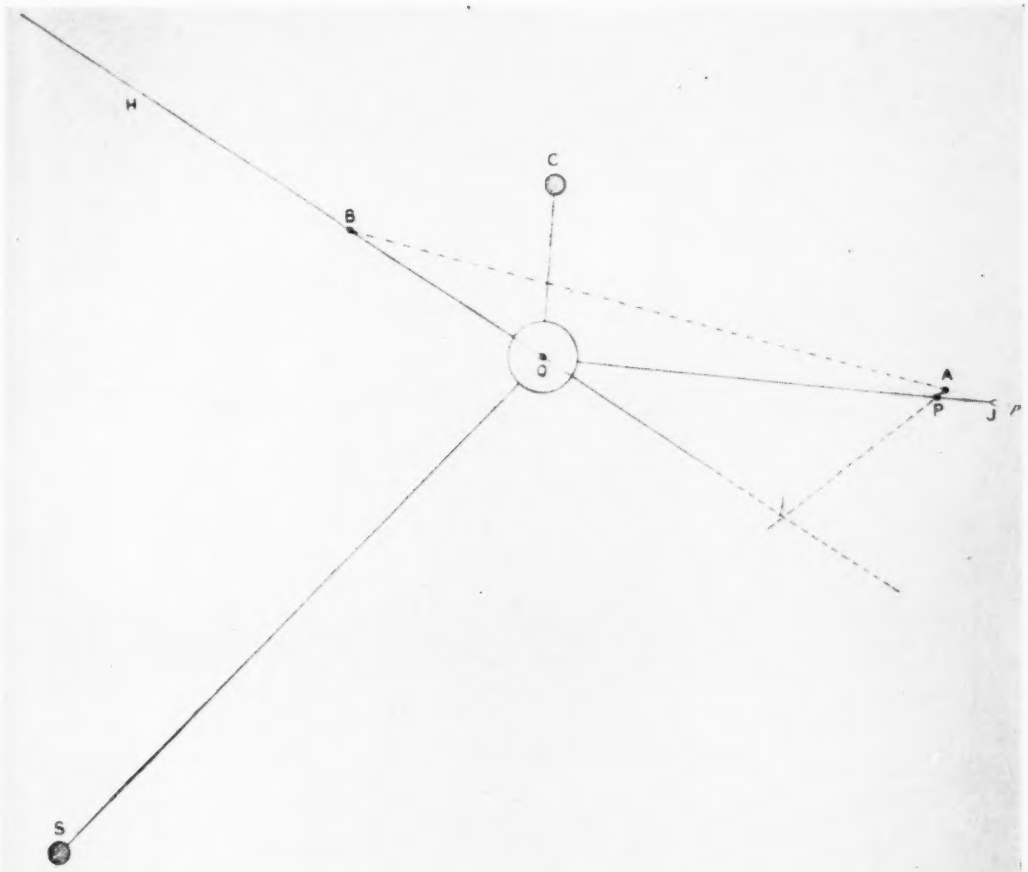


FIG. 7.

Diagrammatic representation of link-work mechanism. There are three moving pieces:—

(i.) The piece consisting of the three arms, Q S, Q C, Q P J, all rigidly connected at Q. This piece represents the moving mandible, C represents the condyle, S the symphysis.

(ii.) The link, H B Q I. It turns about the fixed point B and is linked to the mandible piece at Q. The end H is used as a handle to move the linkwork. (The end I is painted red.)

(iii.) The link, A P I. It turns about the fixed point A and is linked to the mandible piece at P. (The short link A P is almost concealed; its extension P I is the red pointer.)

The jaw, J, and the pin, p, ensure a smooth movement of the mechanism past the position in which the links lie along the line A B. The point, I, in which the lines of the two links intersect at any time, is *the instantaneous centre of rotation of the mandible piece.*

[P is moving perpendicular to P A, and therefore the centre of rotation for the mandible piece is somewhere on the line A P; similarly it is somewhere on B Q, hence it is at I.]

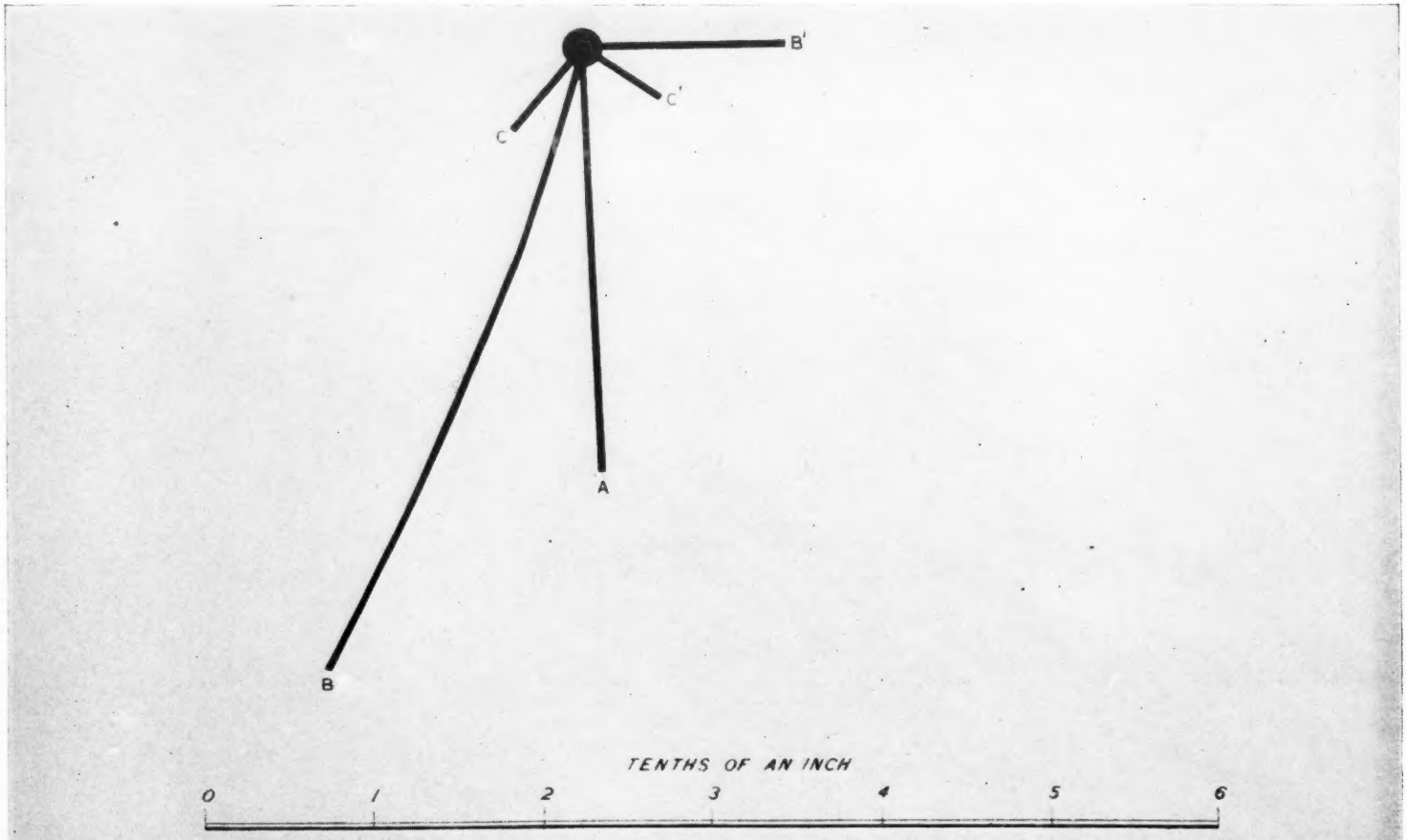


FIG. 8.

To show lateral movements of the condyle. A represents the movement of the condyle during extreme opening of the mouth without lateral movement; B during extreme opening, combined with extreme movement of the mandible to the left; B' during extreme opening, combined with extreme movement to the right; C during extreme movement to the left, with the teeth in continuous occlusion; and C' during extreme movement to the right, with the teeth in continuous occlusion.

lower denture will necessarily be found to be placed too far back; but if the alteration be made in an articulator with the hinge nearly or quite in the plane of occlusion, then the reverse will happen. I mentioned just now that the crosses placed outside the curve, representing the opening and closing movement of the symphysis, indicate extreme forward and backward positions, and it is interesting to note the positions on the condyle path (marked by the same letters) that correspond. The oval curve which might be drawn through these positions of the symphysis show the movement of the mandible obtained by first pushing it forward as far as possible with the teeth in occlusion, then bringing it downwards, then backwards to the extreme limit, and finally upwards and a little forward to reach the position of normal occlusion. The oval curve therefore includes within its area all possible positions of the symphysis.

I will now place on the screen fig. 8. When obtaining this diagram I was sitting facing the wall in order to show any lateral movements of the right condyle. The line A, which is nearly vertical, is produced by extreme opening without lateral movement. You will notice that it deviates slightly to the right; this is somewhat interesting, because I am slightly larger throughout on the right side, and apparently the want of symmetry exists also in mandibular movement. The line B is produced by extreme opening combined with extreme movement to the left. The lines C, C′, belong to extreme lateral movement, with the teeth in continuous occlusion, to the left and to the right. C′ is interesting as showing that, in my case at least, in movement towards the side on which the condyle might be expected to remain stationary there is a quite considerable movement of the condyle outwards away from its articular surface, and slightly downwards. These two movements represent as nearly as possible those of normal mastication. The line B′ is that of extreme opening combined with extreme movement to the right. The condyle again leaves its articular surface to quite a considerable extent, the movement amounting to almost exactly 3 mm.

Now there is one very obvious criticism of these experiments, namely, that they are made upon one individual, and that therefore no general conclusions may be drawn from them. That is perfectly true, but I have carefully refrained from making any general statement as to the movement of condyles. These observations are, however, accurate within very narrow limits, and the work of other experimenters has shown pretty well to what extent the movements of the jaws and the paths of the condyle vary in different individuals; and, although these variations have been shown to be considerable within certain prescribed limits, the movements all have the same general character. Our experiments were conducted especially with reference to the supposedly fixed centre of rotation; there is no such point. If experiments similar to those I have described were made on another individual the paths of the condyle and symphysis would doubtless be found of somewhat different form, and the centrodes necessary to reproduce the movement would be also different; but that there could be for any individual a single centre of rotation is quite impossible, unless his condyle never left its position of occlusion, and then it would be in the condyle itself; or unless the paths of the condyle and symphysis were arcs of concentric circles, and this would involve very abnormal anatomical configuration.

I will now indulge in a few speculations as to the bearing of what I have said on the possibility of constructing an ideal articulator.

In the first place it would be necessary to obtain several correlative positions of both condyles and some other point in a simpler way than the one adopted, even though less accurate. It is conceivable that this might be done by means of a number of bites of different heights, each with an outside framework to register the several positions of the condyles. From these the centrodes could be obtained from which to reproduce the movements, and a working articulator might possibly be constructed to imitate Nature.

Secondly, the models of the jaws must be attached to the articulator in such a way that they bear the same positions relatively to the line passing through the two condyles as the jaws themselves. This may be done with the face-bow in connection with any one of the bites taken. In this way it might be possible to reproduce the natural movement of any individual mandible, but there would yet remain the question of finding the correct height of the bite and the correct plane of occlusion. These two considerations are really distinct from the question of the construction of an ideal articulator, and are connected with the fact that in edentulous and many other cases disease has destroyed the normal conditions.

After all, I do not feel at all convinced that the ideal natural articulator is a *sine qua non* for practical prosthetic dentistry. In constructing artificial dentures we are concerned only with the smallest degrees of openings and with lateral movements with the teeth in occlusion, and I believe that for these purposes a small movement of rotation and translation, combined with some lateral freedom of the correct kind, would probably be sufficient, if there were a scientific method of fixing the plane of occlusion in relation to the condyles when the normal occlusion has been lost. On this point I hope to have something to say at a later time, but, as several years have elapsed since I made the experiments which I have only now described, I am able to assure you that you need have no fear of being troubled before a somewhat remote date.

In conclusion, I should like to say what you have already probably suspected, namely, that this paper would never have been written by myself unaided. I am greatly indebted for his assistance to my brother, Mr. G. T. Bennett, Fellow and Mathematical Lecturer of Emmanuel College, Cambridge. He collaborated with me in the experiments themselves, instructed me in the mathematics bearing on the problem, and drew the charts derived from our direct observations; and although I have managed to write the paper itself, he has also kindly revised it and saved me from making any confusion in mathematical expression. The problem is, in fact, more geometrical than anatomical, and I cannot help thinking that more frequent collaboration between workers in different fields, meeting on border-line subjects, would result in the elucidation of questions which present much difficulty to the specialist. It is one of the inherent weaknesses of specialism that its exponents must become limited to following the natural trend of their own habits of thought; and it is indeed very refreshing to find that just that aspect of a problem which presents most difficulty to the solitary worker is really only a special case of a general truth well known to a student of another branch of science.

DENTIST, DENTAL LABORATORY, AND THE PATIENT

A. H. GRUNEWALD, D.D.S., M.S.*
Northwestern University, The Dental School, Chicago, Ill.

THE COOPERATIVE AND THOROUGH efforts of the dentist and the dental laboratory are essential to the welfare of patients in need of prosthodontic service. This is especially true if prosthodontic service is rendered in any volume. With the current dentist-patient ratio, and the number of new dental graduates versus the population increase, dentists must learn to employ auxiliary personnel more extensively and properly. This applies to both dental office assistants and prosthetic technicians. For years, we have been teaching dental office assistants how to assist dentists. However, this is only one-half of the answer, and a concerted effort is being made to teach the dentist how to use the assistant. It seems that dentists have much to learn also, regarding the use of prosthetic technicians, and further knowledge in this regard could benefit everyone, including the patients.

Along with the increased need for auxiliary personnel, there appears to be an increasingly strained relation between dentist and prosthetic laboratory technician. This is not good. Various reasons are given for this strained relationship. The prosthetic dental laboratories are accused of encroaching upon the rights and privileges of the dental profession, some of which is true. The dentist, in turn, is accused of not meeting his responsibilities, of shifting some of these responsibilities to the dental laboratories, and charging the patient as though he had met them himself. Some of this is true.

I have been told of instances in which dentists have taken patients to dental laboratories for the purpose of obtaining the help of the laboratories in accomplishing a satisfactory impression or other prosthodontic treatment procedure. This might be acceptable if the person associated with the dental laboratory and providing such assistance was a dentist, but otherwise it is intolerable.

Prior to my recently being placed on the Navy retired list, it was necessary for me to obtain a complete physical examination. I was admitted to and remained in a hospital for ten days for this purpose. It is interesting that during this period I had blood drawn six times, had dye injected into my blood stream, had pyelograms and other roentgenograms made, had an ECG, B.M.R., and numerous other tests made without a physician present. During my entire stay in the hospital, I saw five different physicians who spent a total of approximately two hours with me. Not one of them seemed a bit concerned about the possibility of any technician

Read before the Academy of Denture Prosthetics, Columbus, Ohio, May 3, 1957.
Received for publication, May 3, 1957.
*Professor and Chairman, Prosthetic Department.

taking over any phase of medicine. I feel I had a good examination and also learned something about the use of auxiliary personnel.

In contrast to the physician, many dentists fear that the prosthetic dental laboratories are out to, and will, usurp professional functions. If we were to go so far as to admit that this trend exists, we should recognize at once that it cannot be stopped by legislation, as some seem to think. *It can be eliminated only by the dentist's knowing and meeting his responsibilities.* That raises the question as to what the dentist's responsibilities are in prosthodontics.

RESPONSIBILITIES OF THE DENTIST

First, the dentist must recognize that the satisfaction associated with rendering an excellent prosthodontic service outweighs that derived from receiving a good monetary return. This is a fact that is far too often forgotten in this day and age. Second, the dentist must realize that his dental degree, per se, does not entitle him to assume an aloof, smug attitude toward the prosthetic technician and to demand the technician's respect, as well as excellent workmanship, the year around at January sale prices. Third, the dentist must know the basic principles underlying and be capable of competently accomplishing the prosthodontic procedures for which he alone is supposed to have the training, and which require the presence of the patient to be accomplished. The number of these procedures will vary, of course, with the accessibility of the technician's services. For example, sending an impression any great distance for cast pouring is not an acceptable procedure. Assuming that the availability and competence of the technician's services at least closely approach the ideal, the dentist must be capable of accomplishing certain procedures competently in order to render a satisfactory complete or partial denture service.

Forty-five of the forty-seven dental schools in this country currently employ the Hanau Model H articulator in their prosthetic teaching programs. Assuming the employment of an acceptable technique and the Hanau articulator for the construction of complete dentures, the dentist should accomplish the following procedures as a minimum: (1) Complete the oral examination and diagnosis, (2) make the impressions, (3) contour the wax occlusion rims, (4) establish the vertical dimension, (5) obtain a face-bow registration, (6) establish unstrained maxillomandibular relations, (7) determine the plan of treatment, (8) select the teeth, (9) alter the trial setup as indicated, (10 provide the postpalatal seal and outline the palatal relief, (11) remount the dentures and equilibrate the occlusion, (12) insert and adjust the dentures, and (13) provide the proper follow-up service.

This entire article could be devoted to a discussion of item 11, remounting the dentures and equilibrating the occlusion. Suffice it to say that, only through the dentist's assuming direct responsibility for this step can he be sure that processing errors are eliminated, rather than further accentuated in the finished dentures.

Where partial dentures are concerned, the dentist should: (1) complete the oral examination and establish the diagnosis, (2) accomplish the necessary mouth preparation, (3) make the impressions, (4) survey the casts, outline the treatment plan, and design the prosthesis, (5) obtain a face-bow registration when indicated,

(6) establish the maxillomandibular relations, (7) select the teeth, (8) alter the setup as indicated, (9) remount the dentures and equilibrate the occlusion when indicated, (10) insert and adjust the prosthesis, and (11) provide the necessary follow-up service.

To accomplish these procedures properly, the dentist must have a thorough basic knowledge of prosthodontics and a sufficient degree of skill and digital dexterity. This combination will provide the foundation and confidence necessary to direct and utilize the services of prosthetic technicians properly. Certainly, every member of this Academy knows that, due to the research and clinical findings of the last decade, there is more to the field currently encompassed by the term "prosthodontics" than can be mastered in a lifetime. Also, with the fund of knowledge he has acquired by his continued efforts in this direction, the prosthodontist worries no more about the technician usurping his role in life than do the physicians I mentioned previously. But, what about the more recent dental graduate?

UNDERGRADUATE TRAINING

Far too many recent graduates lack the confidence to meet their responsibilities and properly utilize prosthetic technicians in rendering a prosthodontic service. Unfortunately, this lack of confidence stems from a lack of sufficient training and experience in the undergraduate dental school. There must be better yet untried ways of providing additional training and experience in the time normally allowed for teaching undergraduate prosthodontics. However, only so much can be accomplished in a given time, and proper recognition of the need for added undergraduate prosthodontic teaching time would go a long way toward alleviating the present general concern regarding dentist-dental laboratory relations. It is all right to say that the dental graduate can obtain additional training through postgraduate courses. They can and should but, for many reasons both logical and illogical, too many never do. Instead, they look to the gadgeteers for a short-cut answer to their problems. They jump right over the simple $35.00 articulator, that which they failed to learn to use properly and have sitting in the corner, and buy one for $350.00 which some good salesman implies will do their thinking for them. No prosthodontist can learn to run before he learns to walk, and it is time that this fact is brought home more explicitly to a great number of dentists.

Dentistry is an energy-consuming profession, and most dentists are so tired at the end of a busy day in the office that they are not prone to devote further evening effort to study. Studying is a habit. Undergraduate students are in that habit and should be provided ample time, opportunity, and stimulation to acquire a broad, sound knowledge of the basic principles of prosthodontics during this training period. The undergraduate student must also acquire sufficient digital dexterity and competence during his undergraduate years. All of this requires time—time which appears to be all too short in the present-day dental school curriculum. However, since sufficient time is so essential to the solution of the problem with which this article is concerned, an organized effort to acquire it might be in order. Such an effort would be consonant with the objectives of this Academy. Accordingly, it might be exceedingly important and worth while for this group to make a

thorough study of this problem. Perhaps such a study, if undertaken in the true light of all currently existing circumstances, would lead to some new and better answers regarding the time factor in dental education. Is it entirely a matter of getting more time, or, if more time is simply not available, can better use be made of the time that is allotted to principles and practice of prosthodontics?

CONFIDENCE

Another important factor in dentist-dental laboratory relations is the lack of confidence that exists between the dentist and the laboratory. Too often this is due to a mere misunderstanding regarding technical factors. Lack of confidence results in poor personal relations.

Good dentist-dental laboratory relations can usually be established and maintained at the desired level by the dentist employing one of the better laboratories. Some of the distinguishing characteristics of the better laboratories are that (1) their cooperation goes beyond fast service, cost, and credit, and includes the proper consideration for design, materials, and technique; (2) their personnel is interested in self-improvement and attend appropriate meetings and courses; (3) they never stress price as a means of getting business; (4) they admit that they are human and make mistakes and do not attempt to cover up errors rather than ask the dentist to re-accomplish a procedure; (5) they use materials which meet the American Dental Association specifications whenever possible; (6) they are capable of properly employing an adjustable articulator; (7) they voluntarily return work to the dentist for inspection and approval, when it is doubtful, before proceeding with the next step; (8) they normally return partial dentures on the master cast, showing evidence of consideration for the survey and design; and (9) they do not assume the right to include unsolicited procedures in the service they have been requested to provide.

Good relations can be further established and maintained when the dentist recognizes a few do's and don't's in employing a good laboratory which is willing to cooperate in the sole interest of a better prosthesis. (1) Do not expect miracles; dental technicians are not magicians. (2) Do remember that the finished product can be no better than the foundation furnished, such as mouth preparation, impression, cast, etc. (3) Do confer with the laboratory regarding a partial denture design, when indicated. (4) Do allow adequate time. (5) Do expect to make final adjustments in the mouth. (6) Do not demand that the laboratory accept responsibility for the success of a denture. (7) Do not limit general concern regarding the laboratory work to delivery on time. (8) Do visit the laboratory occasionally to check the construction of the prosthesis, and especially when difficult procedures requiring detailed instruction are involved. (9) Do not ask any laboratory technician for information or advice on a professional subject. The technician has no formal professional training. (10) Do offer constructive criticism in such a way that it is recognized as constructive. (11) Do assume the role of a teacher, and make sure that technicians are provided an opportunity for self-improvement by means of clinics, etc. (12) Do get together with the laboratory regarding any new technique to be employed, and thoroughly acquaint it with the procedures. Do

not just assume that the new technique is already being accomplished for other dentists.

PROOF STEPS

It has been suggested by a laboratory owner that the desired relationship between dentist and dental laboratory can best be established and maintained through the use of proof steps for various phases of the technique being employed. The dentist often feels that the laboratory technician has erred if the finished product is unsatisfactory. In such cases, the laboratory technician, on the other hand, feels that the dentist failed to accomplish his phase of the technique properly. Proof stepping could be employed to check many laboratory procedures and thus eliminate misunderstanding regarding the responsibility for possible errors. For example, in order to check for processing errors, the dentures can be returned to the articulator prior to removal from the casts. This proof step would have to be accomplished by the dentist. Others can be provided by the laboratory technician and can be well worth the additional time they require.

PRESCRIPTIONS

An additional means of eliminating misunderstanding and improving dentist-dental laboratory relations is through proper direction, prescription, or order. This is now required by dental practice acts in 36 states, 28 of which require that it be in writing. In addition to being required by many state laws, the prescription provides: (1) the dentist an opportunity to direct the construction of the appliance through the outlining of specific requirements, and (2) the laboratory with a definite specification delineating his responsibilities.

It appears that many dentists fail to meet their personal, professional, and possibly legal responsibilities by failing to provide the laboratories with a proper prescription. The importance of their meeting this responsibility cannot be overstressed. Time and further undergraduate and postgraduate training should result in continued improvement in this regard.

There are over 6,000 dental laboratories in this country. All but a limited few of these laboratories are interested in serving the dental profession in a competent, ethical manner. Unfortunately, the small number of unethical laboratories do exist, and they are a detriment to the profession, the ethical laboratories, and the public alike. Such laboratories are calloused to the public welfare and indifferent to the essential knowledge requirements for rendering a good prosthetic service. They practice dentistry illegally and will continue to exist until the public is made to understand and appreciate the importance of relying upon dentists who have the essential training background for their prosthetic treatment.

The members of the dental profession can best protect themselves against the illegal laboratories by contributing their share to public enlightenment and fulfilling their own professional responsibilities to the highest possible degree at all times.

It is hoped and felt that the American Dental Association's accreditation program will provide a desired degree of protection to the ethical laboratories, dental profession, and public.

The American Dental Association's Council on Dental Trade and Laboratory Relations has within its approved long-range program* the responsibility:

"1. To maintain for dentistry the complete legal as well as professional responsibility for providing prosthetic dental services to members of the public.

"2. To establish and maintain the effective relations between the dental profession and reputable representatives of the dental laboratory industry and craft.

"3. To establish and maintain the greatest efficiency of the dental laboratory industry and craft."

The foregoing is a most worthy program and deserves our support in every possible way, both as individual dentists and through our local dental societies.

311 E. Chicago Ave.
Chicago, Ill.

*Paper presented by Bernard J. Conway, Secretary of the Council on Dental Trade and Laboratory Relations, before the New England State Officers Conference, April 23, 1955.

DEVELOPMENTS IN THE DENTURE FIELD DURING THE PAST HALF CENTURY

VICTOR H. SEARS, D.D.S.
Vallejo, Calif.

HISTORY DEPENDS LARGELY UPON who writes it. One author unconsciously admitted this when he entitled his book, "An Impartial History of the Civil War From the Southern Standpoint." And so what follows should be regarded as a half century of denture history as it looks to me.

The quality of dental graduates in the early 1900's was comparatively low. Most anyone with fifty dollars and a high school diploma could walk into a dental school and matriculate. Some young men did it without either. Some of the states had only recently set up machinery for examinations. Dental societies at the various levels were not so well supported by the profession as they are now. Specialty societies and specialty boards were just beginning to be thought of.

The laboratory work for practicing dentists at that time was mostly rushed through in dingy back rooms of advertising dental parlors and dental supply houses. Dental laboratories independent of advertising parlors and supply houses began to appear about the turn of the century. My father established one of these in 1902. Everything about the laboratory held a fascination for me and I took the opportunity, during vacations from school and during other times, to work at the bench.

EQUIPMENT

The few electric motors available were undependable as was the service of the public utility company providing the current. In the laboratory we used an assortment of Kingsley scrapers to do the finishing of vulcanite and celluloid dentures. The polish and high shine were accomplished with a kick lathe—one of the best devices ever invented for producing a backache. Up through the bench there extended a round leather belt to the lathe which turned slowly even with vigorous leg action.

We continued using bench lathes even after the new-fangled electric motor was installed. I remember well the long steel shafting with pulley wheels attached and which was run ordinarily by a large electric motor, round leather belts running from the pulley wheels to the bench lathes. Often the electric power would fail, so in order to continue working we had a stand-by gas engine. The electric motor or the gas engine, as well as the shafting, made quite a din.

Flasks were made of iron castings which were held together with stove bolts. These flasks were generally wobbly when they were new, becoming more so as they were hammered to knock out the vulcanized dentures, and as they continued to rust.

Read before the Academy of Denture Prosthetics, Colorado Springs, Colo., May 3, 1956.
Received for publication May 3, 1956.

A few years later (1916) brass flasks were just being adopted, but some of the dental laboratory proprietors in Chicago did not dare put them into use for fear that their employees would steal them for scrap metal. "Set-ups" were made on hinge articulators.

If a dentist could get an impression and "bite" to the laboratory before noon, he was promised the completed denture the same day. Speed and price were the principal means of meeting competition. The dentist could have a denture made for as little as two dollars—teeth and rubber included.

Then the dentist put a substantial mark-up on the product, charging the patient $7.50 to $10.00 and occasionally $15 per denture. Extractions were often free.

MATERIALS

Just before the turn of the century the Kerr Dental Manufacturing Company had developed an impression material composed of gum damar and prepared chalk to overcome the objections to builders plaster. This modeling plastic (in those primitive days called modeling compound) made little headway until about 1910, when the Greene Brothers gave courses of instruction in its use, and Jacob Greene wrote a book on the subject.

But many of the dental laboratories would not accept "modeling compound" impressions, and others made an extra charge if it was used. Its popularity continued for a decade, and it is still the material of choice with a few men. In 1916 and 1917, I organized classes taught by Wilfrid J. Holroyd, Samuel G. Supplee, George P. Brenner, Milus M. House, and others at which modeling plastic techniques were taught almost exclusively.

In addition to classes in impression making, classes in denture construction and especially in tooth arrangement were given by the Dentists' Supply Company. As a further contribution, this company also issued two well-illustrated books featuring new anterior and posterior tooth forms. The books were *Prosthetic Articulation* by George Wood Clapp in 1914, and *Professional Denture Service* by George Wood Clapp and Russell Wilford Tench in 1918.

Any account of the development in denture service would be incomplete without mention of the part played by our present organization, which bore the temporary name of "International Society of Prosthetists," and was launched at New Orleans in 1919 as the "National Society of Denture Prosthetists." The name was later changed to the "Academy of Denture Prosthetics."

There are three historical accounts of the organization: in the *Dental Digest* of December, 1919, in the 1928 program of this Academy, and again in the 1949 program. They all three agree that the first scientific meeting of the organization was held at New Orleans in 1919. On other matters there is considerable disagreement, again tending to show that history depends largely on who writes it.

A study of available records indicates that our organization was more than anything else sparked by members of the Detroit Dental Clinic Club. This club, organized in 1914, presented its first denture clinic in 1916 and has been active in the field ever since. Four members of the club who prepared this first clinic saw the possibility of, and the need for, a national organization similarly dedicated.

They started working to this end by interesting leading prosthetic men from other parts of the country. The names of these four pioneers are Wm. A. Giffin, Charles Lane, P. C. Lowery, and A. Alfred Nelson.

The founding of the National Society of Denture Prosthetists was an important step in the development and harmonizing of denture prosthetics. Before 1919 there were individual leaders with personal followings and more or less individual viewpoints, each claiming superior theories and techniques. The National Society of Denture Prosthetists brought most of these leaders together where their claims were appraised by the membership. Conflicting ideas were hotly debated, and it became more and more evident to most of us that intensity of belief is no measure of the truth.

A few members of the original group were unable to stand the questioning and criticism that was meted out to all alike. They dropped out of the organization to their own detriment, but most of the members remained and learned to give and take in a friendly spirit.

Other prosthetic organizations have since been established, and all of them are on friendly terms with one another.

Another important factor contributing to progress has been the role of the dental manufacturers. Our profession is being well served by the manufacturers of high quality materials and equipment.

There are so many phases of our work that they cannot all be treated in a report of this length, but it might be profitable to pick out for discussion a few items such as artificial teeth, denture bases, and articulators.

ARTIFICIAL TEETH

Fifty years ago artificial anterior teeth were supposed to be carved according to the now discredited temperamental theory. There were a few pleasing molds available but most of the molds were appropriately termed "false teeth."

As for posterior teeth, their occlusal surfaces were what might be termed "cobble stone." A few so-called "anatomical" molds were coming on the market, but they were evidently not carved by dental anatomists. They were devised generally by employees in the tooth factories who were neither anatomists nor engineers.

In 1914, J. Leon Williams carved some improved anterior forms based on the F. H. Berry "discovery" that the outline of the patient's face furnishes the outline form of the upper central incisor. This questionable theory was built into the typal theory of square, tapering, and ovoid teeth still believed in by many dentists.

Unsuccessful attempts were made to induce recognized anthropologists to substantiate the typal system of tooth selection. Even without this backing, the idea was pretty well sold to the dental profession. Among others, Walter Henry Wright and M. Russell Stein have written articles showing the fallacy of this theory, but there still remains a lively belief in it.

At the same time that the Williams' improved forms were introduced, new and sharper occlusal forms were devised by Alfred Gysi. These new forms had greater cutting efficiency than the teeth then in general use, but they also produced greater interference to eccentric jaw movements. Tooth manufacturers in general went quickly to similar forms with higher and sharper cusps.

This change was hailed by many as an unmixed blessing, but we began to have greater difficulty in satisfying our patients. Denture wearers complained more about sore mouths and loose dentures. As one result, we had an era of "tissue chasing" in which refitting and remaking increased. Toward the end of this high cusp trend (in the 1920's) we went to extreme lengths. Deep locking cusps were carved and were used by a few denture men around the country, but the increased difficulties with sore mouths and loose dentures prevented any wide acceptance.

Sometimes the patient would grind away the high cusps if the dentist would not. Dentists who continued to use these teeth usually did considerable "modifying" of the occlusal surfaces before the dentures were delivered. Thus they arrived the hard way at more or less nonanatomic occlusal forms while proclaiming that they used high cusped anatomic teeth. Perhaps the advent of the extra high cusped teeth helped to point the way to more suitable occlusal forms, as well as to stimulate greater interest in impressions.

Soon after the introduction of higher cusped teeth, the most popular subjects on dental society programs were how to make tighter bases, and how to rebase dentures to compensate for tissue shrinkage. It did not at first seem to occur to us that our troubles might be due in large part to occlusal interference.

When tighter bases proved disappointing, we next looked to our casts. S. J. Spence had marketed his composition for making hard casts about 1913, but this material met with little success. Then in 1916, Louis J. Weinstein produced his "Dentolith," the first of the so-called artificial stones which are in general use today.

We next directed our attention to dental articulators in the hope that more accurate reproduction of jaw movements might be the answer.

NONANATOMIC TEETH

Some of us felt, however, that the problem would not be solved until we could make and use teeth with special occlusal patterns designed to permit the patient to chew without placing too great horizontal force on the denture-supporting structures. The outcome of this line of thinking was the nonanatomic occlusal scheme.

The first of the present line of nonanatomic teeth came to the attention of the National Society of Denture Prosthetists in 1922 with a paper and clinic. A history of the continuous development in this field is available in the literature. In 1927, the concept was presented before the American Dental Association at its annual meeting and Channel teeth were placed on the market. Also in 1927, the Gysi Cross Bite teeth were described in a series of articles in the *Dental Digest* and placed on the market in 1929.

Cross Bite teeth were a departure from the orthodox forms without being frankly nonanatomic. In spite of the fact that Gysi himself estimated that 60 per cent of all denture patients would be better served with Cross Bite than with ordinary teeth, and in spite of the promotional efforts of the manufacturer, these teeth enjoyed only transient interest.

As for the frankly nonanatomic forms there was at first little general interest by the profession, but quick antagonism from some of the manufacturers. These manufacturers called the whole idea a fad and "irrational." However, the nonanatomic concept has now been accepted to the extent that the array of frankly

nonanatomic forms in today's dental supply depot no longer causes the dentist to arch his eyebrows. What was once freakish has become commonplace; what was once irrational has become rational. Of course, the end is not yet, and even more appropriate forms are being developed.

Another important development in artificial teeth began about 1939. In that year, three men presented clinics on plastic teeth—handmade, of course. The three men were A. Alfred Nelson of Royal Oak, Michigan, E. Byron Kelly of Chicago, and William E. Wilson of Springfield, Illinois. The idea seems to have occurred to all three men independently.

Three years later, methyl-methacrylate teeth were marketed by the H. D. Justi and Sons Company. Other maufacturers soon followed. In 1944, the Justi Company discontinued the manufacture of porcelain teeth, making only plastic ones since that time.

About 1943, the Myerson Tooth Corporation enlisted the help of Clark Smith and E. Byron Kelly and set up a laboratory in Boston to develop a better plastic tooth material which would overcome the disadvantages of methyl-methacrylate used up to that time. After considerable experimental work, the company developed the first cross-linked copolymer tooth material which they named Dura Blend and they placed the teeth on the market in 1948. Other companies have since produced copolymer tooth materials.

A further development in the use of tooth materials is the combining of different materials in the same set of teeth. At present, this is implemented by the use of plastic occlusal surfaces against porcelain ones, but the idea is susceptible of further development.

DENTURE BASES

The material in general use for denture bases fifty years ago was vulcanite. In 1911, Dayton Dunbar Campbell developed a technique for casting aluminum bases in a cow bell which was popular for a while. Even where gold or aluminum bases were cast or swaged, vulcanite was the material for attaching the teeth. Properly handled, good vulcanite was rather well suited to denture construction except from the standpoint of appearance. Much of the dissatisfaction with vulcanite was due to inferior materials in its manufacture, and careless or improper handling in the laboratory.

In an effort to overcome the esthetic disadvantage of vulcanite, we resorted for a while to the use of veneers. The first one I remember was a product marketed by the deTray Company about 1916 under the trade name of Protesyn. It was beautiful to look at when first applied but porous and fragile. It was followed by Nelson's Tissue Blend—actually a composition of waxes—and later by Ixolain and other veneers. Perhaps the fact that even these unsatisfactory veneers were used at all stimulated the search for improved denture base materials. Slight modifications of celluloid came on the market in the early 1920's: Hecolite, Hodite, and others.

By 1925 we were using phenol-formaldehyde condensites, under the trade names of Porcelite and Iteco and later Luxene 37, which usually turned from a rosy pink to an orange brown and were extremely brittle.

A few years of this and, about 1933, we turned next to a sort of glorified sluggish thermoplastic that behaved somewhat like celluloid but was actually a vinyl-chloride-vinyl-acetate copolymer. This product manufactured by the Union Carbide Company was marketed under the name of Resovin by the S. S. White Dental Manufacturing Company and under the name of Vydon by the Lee S. Smith Company.

There appeared many other competing materials sold with great claims, but the field testing was left to the practicing dentists instead of being done by the manufacturers. In 1941, I made a list of 51 different trade names of denture base materials which were on the market then, but which are now no longer offered.

During this rash of materials, methyl-methacrylate was developed for denture bases and has supplanted nearly everything else for the last twenty years. In 1936, the Vernon Benshoff Company supplied a few of us with experimental material in gel form. It came with the endorsement of Walter Henry Wright and in the following year was placed on the market under the trade name of Vernonite. The next year the Kerr Dental Manufacturing Company marketed a similar material in powder and liquid form under the trade name of Crystolex, followed closely by another powder and liquid product called Lucitone made by the L. D. Caulk Company.

No further improvement in denture base materials of any great consequence appeared until 1948 when a styrene copolymer plastic was developed by Charles Dimmer in cooperation with the Dow Chemical Company, and marketed in 1950 together with special equipment necessary for its transfer injection into a dry mold. This material, Jectron, has great strength, but its chief advantage over methyl-methacrylate, as generally processed, is greater accuracy and permanence of adapted form.

The latest development in denture bases appeared this year, and is being demonstrated by Clark Smith, the inventor, and Emmett Beckley. Any of the present methyl-methacrylate formulas can be used in this method known as Hydrocast. The special equipment and technique are based on the assumption that while contraction of the material cannot be prevented, it can be controlled so that the least distortion is made to occur next to the cast where the greatest accuracy is required.

Aside from improving the physical properties of the bases, increased attention has been directed recently to the esthetics of the materials. Natural gum contours and variegated coloring found in natural gums have been more closely imitated—even exaggerated.

Other improvements are sure to follow, but there is a vast difference between the denture bases of today and those of fifty years ago.

ARTICULATORS

The Gritman and the Kerr Anatomical Articulators were available fifty years ago, but were pretty much ignored by the dental schools and by dentists in general. A few Gysi Adaptable Articulators, handmade in Switzerland in 1910 and high priced for the times ($50), were in the hands of the elite in 1913. But it was

not until 1920 at the Boston meeting of The National Society of Denture Prosthetists that articulators became the subject of hot debate and general interest. George S. Monson, Alfred Gysi, Rupert E. Hall, and Rudolph Hanau dominated the Boston meeting with their conflicting ideas, and the controversy continued for several years. This interest stimulated many others to design articulators, quite a number of which reached the market. Although developments still continue, it is probably safe to say that the early 20's pretty much settled the articulator issue, and the profession turned its major attention to other matters.

OTHER DEVELOPMENTS

There are other items such as dental flasks, tracing devices, implant dentures, impression materials, roofless dentures, magnets, soft denture liners, medication, surgical mouth preparation, and immediate restorations that might be included to make this discusson more nearly complete. However, enough phases have been considered to give some idea of progress made in the last half century.

Mention should be made of the JOURNAL OF PROSTHETIC DENTISTRY which started publication in 1951. Under capable editorship and management this JOURNAL has done much to advance our specialty and to make the proceedings of its contributing societies available to dentists everywhere. By all standards of comparison, it ranks high. Incidentally, the publication of the new *Glossary of Prosthodontic Terms* in the March 1956 issue is an important milestone.

Present activities in the denture field seem to portend no new development of importance except perhaps pertaining to lesions of the temporomandibular joint. This is not strictly a denture problem, although denture men are at present the ones most active in the study. New interest in this field prompted the founding of the American Equilibration Society, which held its first scientific meeting this year. The study opens up a vast field in which the dentist needs the help of other branches of the healing arts. It is a field of investigation that should bring physicians and dentists closer together.

In this review we have considered only a few of the past accomplishments in the field of denture service. Speculation as to the possible developments in the next fifty years are highly intriguing and should stimulate us to more intense effort. From present indications, we can expect the rate of progress to accelerate.

646 WASHINGTON ST.
VALLEJO, CALIF.

DISCUSSION* of *Developments in the Denture Field During the Past Half Century by Victor H. Sears, D.D.S.*

O. M. Dresen, D.D.S.
Milwaukee, Wis.

I WISH TO COMPLIMENT Dr. Sears on the presentation he so ably made in depicting the progress in prosthetic dentistry during the past fifty years. The advances made in complete denture prosthesis during the past half century are closely allied with all advances in dentistry and in dental education. This was also the era of progress and improvement in all fields of dentistry. This development, along with the recognition of the value and importance of the biologic sciences, raised dentistry from a mechanical art to that of a true profession. While some disapproved for a time of the diversion of time in the curriculum of a dental school from the mechanical arts to the sciences, I believe that today we realize that any program of dental education must be arranged and balanced so as to provide learning and education on a professional level, so that the experience will be so diversified that all areas will receive recognition, and the dental graduate—the end result—will emerge from this experience as a well-educated person, a true professional man; one able to assume his proper place in the community in which he will practice.

As described by Dr. Sears, dental education of fifty or less years ago was, in many cases, offered and controlled by the dental dealer and the dental laboratory. Organized research was nonexistent and new products offered to the profession were tried in the dental office on private patients, many times with disastrous or discouraging results for all concerned. Even though organized research was rare, the unity of purpose and design of the profession in those days, at and following the turn of the century, did much to advance the profession and to improve the techniques and art of prosthetic dentistry.

Sears carries you through the developmental period of teeth, materials, and the early articulators and techniques. Inasmuch as he was one of those who was primarily concerned in these improvements, one to whom we listened, and one from whom we learned down through the years, not much can be taken from, or added to, that part of his discussion. He covers it in a complete and interesting manner. Sears also discusses nonanatomic tooth forms and, as he is one of those who pioneered those forms, it is also quite adequately covered. He does say "the end is not yet," and "what was once considered freakish is now common place, and that considered irrational is now fairly rational." Functionally and from practical experience, it seems to me, however, that anatomic tooth forms do provide more masticating efficiency than nonanatomic forms.

Received for publication May 3, 1956.

*Presented before the Academy of Denture Prosthetics, May 3, 1956, at Colorado Springs, Colo.

I too ran the gamut of the "new" denture base materials he describes. Many a vulcanite denture have I packed and polished. It was rather dirty work, too, compared to working on the denture of today. Certainly the property of dimensional change and accuracy of reproduction did seem superior in a vulcanite denture as compared to the change in dimension we experience in many present-day materials. I do particularly remember Resovin and Vidon which seemed to be good materials but which were subject to internal strains which eventually resulted in nearly every denture breaking, and for no apparent reason. Woe the remakes in that era!

It would seem that, with the present knowledge of chemistry and of the changes that occur in denture base materials, a base will or should be developed soon that will overcome all of the shortcomings of those with which we now labor.

In considering prosthetic dentistry for the past fifty years, we should also consider those individuals concerned with the growth and development during this era, and with the elevation of prosthetics from a mechanical art to an important part of a profession serving the health needs of many people. To mention all of those concerned would be almost a Who's Who of Dentistry. There are, however, some who deserve special mention.

William Giffin, Charles Lane, A. A. Nelson, and P. C. Lowery were active in the formation of the International Society of Prosthetists in Chicago in 1918, which had its first meeting in New Orleans in October, 1919. There were others involved also: M. M. House, Dayton Dunbar Campbell, Claude Stansbery, Russell Tench, Lester Furnas, William Cummer, Alex Patterson, George H. Wilson, E. H. Mauk, Rupert Hall, E. B. Owen, George Wood Clapp, Victor Sears, Robert Gillis, James A. Graham, F. M. Hight, Edward Bruening, V. C. Smedley, A. K. Parks, Jack La Due, Harry Horner, J. W. Crawford, George S. Monson, Rudolph Hanau, J. Leon Williams, George B. Snow, Alfred Gysi, S. H. McAffe, John W. Needles, Walter H. Wright, George Brenner, Walter Pryor, George Phillips, H. V. Cottrell, E. C. Pendleton, Bert Hooper, and a host of others.

This organization became the National Society of Denture Prosthetists and, still later, the present Academy of Denture Prosthetics. Honor and tribute is due these men for their forbearance and fortitude through the years. Theirs was a unanimity of purpose; and, although often digressing from the commonly accepted pattern, much good came of their efforts and discussions. I have attended meetings since 1925, and it has been a privilege and an honor to know these men and to have seen their devotion to their chosen profession through the years. There have been arguments and heated discussions without number, but it is to the credit of all those who have gone before that a serious rift never did develop in all of the years of existence of the organization. May it so continue for many more years to come.

Many of these men have passed on to their just reward; to a place where all lower dentures have retention, where there are no sore spots, and where every denture is a successful one. Those who have gone and those who remain deserve special recognition for their achievements in their many years in dental practice.

They have made many contributions to the profession for the betterment and improvement of dental health, and have aided in the growth and recognition of

dentistry as one of the major health professions. The heritage they leave us cannot be measured in dollars and cents. Intrinsically, it is a treasure beyond the scope of our imagination, and dentistry will long benefit from the impact, the wisdom, and the educational experience these men and others imparted during the past fifty years.

The past fifty years have been those of the development of a great profession—one that has grown rapidly as a health service, which developed educationally in all areas, both in experience and *in learning*.

These men are the pioneers in dentistry who carried the load at a time when the education of the profession was primarily carried by the progressive members of dentistry and not by the schools as it is today. Though disorganized in a sense, they had a unity of purpose—the development and improvement of a profession and an adherence to ideals.

It was an era of learning and teaching on a give-and-take basis. Many dental offices were engaged in active research projects, as organized efforts on research were sadly lacking.

We cannot recognize the achievements or honor these men enough. Theirs was a trial and error period; and even though their efforts were for the most part unorganized, the results they obtained and gave ungrudgingly to their fellow professional men did much to achieve the present status and the growth that has brought dentistry to its present high plane. They gave it the recognition it deserved as a true profession and endowed it richly.

The growth of dental education was in direct proportion to the activity of the various groups in dentistry, for such development influenced the spread of the dental schools across the nation. As a school progressed in one certain area, others found it necessary to enlarge their programs also.

The progress made during these past fifty years is closely integrated with the lives of these men who, for the most part, had an active part in the development of the dental schools. They made their contributions of time, effort, and knowledge to the schools and thereby advanced the development of learning and teaching programs in all areas of dentistry.

735 N. Water St.
Milwaukee, Wis.

CONTEMPORARY PARTIAL DENTURE DESIGNS

WILLIAM L. MCCRACKEN, D.D.S., M.S.*
University of Alabama, School of Dentistry, Birmingham, Ala.

TO PARAPHRASE MARK TWAIN, "Everyone talks about the preservation of the oral tissues, but partial dentures continue to destroy them."[1-3]

In this article I propose to discuss the design, location, and the purpose of the various components of the partial denture and to point out some of the violations of sound biologic and mechanical principles commonly committed.[4] I realize that commercial dental laboratories fabricate the partial dentures, at least their framework, for most dental offices today.

Those responsible for leadership in the commercial dental laboratories, and in the manufacture of metal alloys for use in partial dentures have tried to provide excellent technical material which, if followed, does a fair job of assuring acceptable partial denture design. However, just as industries like General Motors provide excellent manuals for all phases of servicing and repairs to their products, this alone does not guarantee that the individual mechanic has the background, or the ability, to benefit from this assistance. He may, and too frequently does, prefer to continue doing things just as he learned to do them originally, by apprenticeship.

I am not criticizing the wide use of auxiliary personnel and dental laboratories, but only their misuse and the abuses resulting from inadequate supervision, lowered standards, incompetency, and the lack of professional integrity on the part of dentists.

The "case" on the laboratory bench has never been a mouth nor will it ever be anything but a stone cast upon which the dental technician places a mechanical device. In contrast, when we dentists see a stone cast, it should represent a cast of a patient's mouth, which is the result of careful clinical assessment and the result of an impression made with the most modern materials. The mechanical device which we design for this cast goes into a mouth and represents the interrelationship of living tissues and a mechanical prosthesis. The device may succeed or fail, from a purely mechanical standpoint, depending upon how well it is designed and fabricated. However, it may also fail as an oral prosthesis because biologic principles were violated or were ignored.

In the final analysis, then, it is up to the dentist and his technician to fabricate a dental prosthesis that will succeed both mechanically and biologically. Both parties have their circumscribed responsibilities, and both have their limitations;

This article is being published simultaneously in the *Journal of the Michigan State Dental Association* by special arrangement between the Editor of the *Journal of the Michigan State Dental Association* and the Editor of the JOURNAL OF PROSTHETIC DENTISTRY.
Read before the Michigan State Dental Association, Detroit, Mich., April 10, 1957.
Received for publication May 3, 1957.
*Associate Professor of Dentistry.

but the dentist, by training, should be presumed to have the greater background for biologic design and the greater responsibility for the patient's welfare.

ESSENTIALS OF PARTIAL DENTURE DESIGN

All partial dentures have two things in common. First, they must be supported by oral tissues. Second, they must be retained against reasonable dislodging forces.

If a tooth, which may be used for the support of the partial denture, remains at each end of each edentulous span, then the appliance is a tooth-borne, removable-bridge type of prosthesis (Fig. 1). Three components are necessary. These are: the *connectors,* the *retainers,* and the *bracing* or *stabilizing* components.

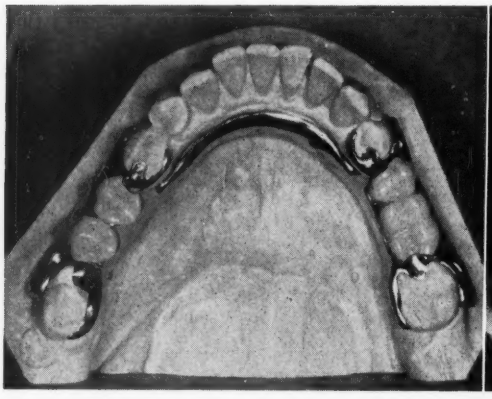


Fig. 1.

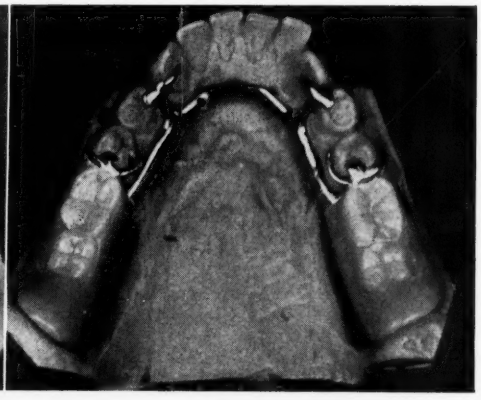


Fig. 2.

Fig. 1.—A removable partial denture which is entirely tooth-supported through the medium of occlusal rests on each abutment tooth. (Kennedy Class III.)

Fig. 2.—A removable partial denture which is both tooth- and tissue-supported through the medium of occlusal rests on the abutment teeth and tissue-supported denture bases. (Kennedy Class I.)

The partial denture that does not have the advantage of tooth support at each end of each edentulous space still has support, but in this instance, the support comes from both the teeth and the underlying ridge tissues, rather than from the teeth alone (Fig. 2). This is a composite support, and the prosthesis must be so fabricated as to coordinate the resilient support rendered by the edentulous ridge and the more stable support offered by the abutment teeth.[5-10] The three essentials —the connectors, retainers, and stabilizing components—must be even more carefully designed and executed because of the movement of tissue-supported denture base areas. In addition, provision must be made for three other essentials.

First, the best possible support must be obtained from the resilient ridge tissues. This is accomplished by the impression technique more than by the partial denture design, although the amount of area covered by the partial denture is a contributing factor in such support.

Second, the method of direct retention must take into account the inevitable tissueward movement of the free-end denture bases under the stresses of mastication and occlusion. Direct retainers must be designed so that some flexing or

stress-breaking under occlusal loading will occur instead of transmitting torsion directly to the abutment teeth.

Third, the partial denture having one or more free-end denture bases must be so designed that movement of the unsupported and unretained end away from the tissues will be prevented or minimized. This is often referred to as indirect retention, and is best described in relation to an axis of rotation through the occlusal rest areas of the principle abutments. However, retention from the partial denture base itself can frequently be made to prevent this movement of the denture base away from the tissues and, in such instance, may be spoken of as direct-indirect retention.

The remainder of this article will deal with the proper design and the frequent violations of the principles involved in each of the essentials named.

Fig. 3.

Fig. 4.

Fig. 3.—The abutment teeth are splinted by means of two crown restorations soldered together (left) or by a fixed partial denture (right). This results in the equivalent of multi-rooted abutment support.

Fig. 4.—The precise occlusal rest outline form indicated on the master cast is a part of the specific design of the partial denture framework.

OCCLUSAL RESTS

The support of the partial denture by the abutment teeth is dependent upon the alveolar support of those teeth, the rigidity of the partial denture frame in that area, and the design of the rest itself. Through clinical and roentgenographic interpretation, the dentist evaluates the abutment teeth and decides whether or not they offer adequate support. In some instances, the splinting of two or more teeth is advisable, either by fixed bridges or by soldering two or more restorations together (Fig. 3).[11] The dentist has the sole responsibility for the preparation of the abutment teeth for crowns and the design of those crowns. In other instances, a tooth may be deemed too weak for abutment support, and extraction is indicated in favor of obtaining better support from the adjacent tooth.

Having decided upon the abutments, the dentist is solely responsible for the form of the occlusal rest seats, which are prepared either in sound tooth enamel, or in metallic restorations.[12,13] The technician cannot be blamed for inadequate

occlusal rest support. On the other hand, the technician is solely to blame if he extends the casting beyond or fails to include the total prepared area. If a definite occlusal rest form with the floor of the rest inclined toward the center of the tooth is faithfully recorded in the master cast and delineated in the penciled design, no excuse can be made for poor occlusal rest form (Fig. 4).

MAJOR CONNECTORS

The proper form and location of a lingual bar is presumably well known to every dentist. Does your technician know and conform to these principles? Do you insist that certain principles are not violated, or do you accept whatever violations he incorporates into his design? A little review of these principles will do no harm.

The lingual bar should be properly located in relation to gingival and moving tissues, and it should be of sufficient bulk to be nonflexing, tapered superiorly with the necessary half-pear cross-section form, and with sufficient, but not excessive, relief over the tissues.

Frequently, we find lingual bars located high against delicate tissues, sometimes with insufficient relief, but more frequently with excessive relief and of some nondescript strap or half-round form. A still more prevalent violation of principle is in the lack of the rigidity so necessary to the proper distribution of forces to and from the supporting components.

The addition of a secondary or Kennedy bar, or a lingual plate, does not change the basic principles of the lingual bar design. They are added solely for reasons of support and protection to the anterior teeth, and are neither connectors nor indirect retainers. This fact is apparently unknown to the technician.

In the upper partial denture, rigidity of the major connector is just as important, and its location and design are just as critical. An arch-shaped palatal casting is rarely justified except to avoid a palatal torus. Likewise, a single palatal bar cannot be justified. The former must be either bulky or flexible and injurious to gingival tissues; the latter is usually flexible and annoying to the patient by its location and bulk. The anterior and posterior palatal circle (double bar) on the other hand is mechanically and biologically sound and cannot be criticized if it is so located as not to impinge upon tissues (Fig. 5). My personal preference is the anatomic palatal strap or palatal plate (Fig. 6). It provides rigidity, greater patient comfort, and greater stability without tissue damage. In addition, direct-indirect retention which frequently eliminates the need for anterior indirect retainers is obtained.

The true test of any major connector is its rigidity and the damage done to oral tissues.

DIRECT RETAINERS FOR TOOTH-BORNE PARTIAL DENTURES

Retainers for tooth-borne partial dentures have only one function, and that is to retain the prosthesis against reasonable dislodging forces without damage to the abutment teeth while they pass to and from their terminal positions. There is no movement of the prosthesis tissueward because each terminus is supported by an occlusal rest. There can be no movement away from the tissues and, therefore, no rotation can occur because each end is secured by the action of a direct retainer.

Any type of retainer is acceptable as long as the abutment tooth is not jeopardized by its presence. Intracoronal (precision) retainers are ideal for tooth-borne appliances and offer esthetic advantages not to be found in the extracoronal retainers. Nevertheless, the circumferential and bar type retainers are just as effective and are more economically constructed than intracoronal retainers. Therefore, they are more universally used.

Vulnerable areas on the abutment teeth must be protected by restorations with either type of retainer. The clasp retainer must not impinge upon gingival tissues. The clasp must not exert excessive torque upon the abutment tooth during insertion and removal. Therefore, it must be placed at the least acceptable distance into the tooth undercut for retention, and it must be designed to have the least acceptable bulk and tooth contact.

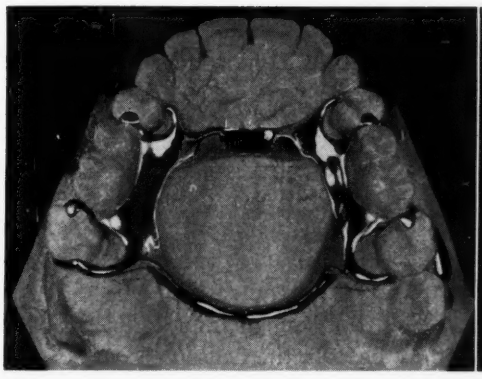


Fig. 5.

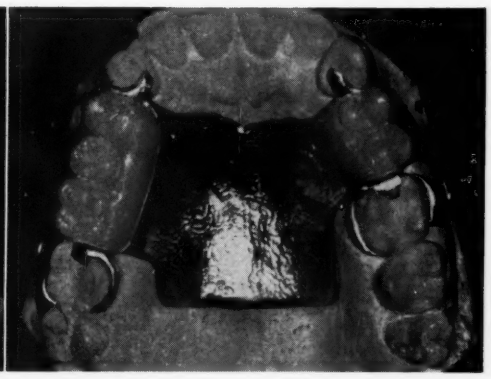


Fig. 6.

Fig. 5.—Anterior and posterior palatal bars as major connectors in an upper partial denture design.

Fig. 6.—An anatomic palatal strap major connector in an upper partial denture.

Fig. 7.—A Roach or bar retentive clasp improperly used. The clasp is too near the occlusal surface of the tooth, covers an excessive amount of tooth surface, is unsightly, and lacks the flexibility necessary to a free-end partial denture.

The bar or Roach clasp[14] (Fig. 7) is used by some technicians as if there were no other types of clasps. Actually, it should be used only where the area for retention lies close to the gingival margin of the tooth and where little tissue blockout is necessary. If the clasp lies high occlusally, or if an objectionable space exists be-

tween the bar and the tissues, then the clasp has not been wisely chosen, and a circumferential clasp should have been used.

Some of the recently devised concepts of clasp design, conceived for esthetic reasons, engage vulnerable areas of the abutment teeth and are to be condemned when used on unprotected abutments. The dentist must evaluate patient caries susceptibility and oral hygiene habits carefully before resorting to such designs, and he must assume the responsibility for placing protective abutment restorations.

DIRECT RETAINERS FOR FREE-END BASE PARTIAL DENTURES

Retainers for free-end base partial dentures, while retaining the prothesis, must be able to flex when the tissue-supported denture base moves under function. Stress-breakers accomplish this adequately, but they do so at the sacrifice of horizontal stability. The user of stress-breaker designs should recognize that he is placing added responsibility upon the edentulous ridge for horizontal stabilization, and the denture flange must be able to act to prevent horizontal movement. However, stress-breakers can be justified in some instances when they are wisely and intelligently used.

Clasp designs that allow for flexing of the retentive clasp arm may accomplish the same purpose without sacrificing horizontal stabilization. Generally, this can be done with less complicated techniques. In evaluating the ability of a clasp arm to act as a stress-breaker, one must realize that flexing in one plane is not enough. Rather, the clasp must be freely flexible in any direction, as dictated by the stresses applied. Bulky, half-round clasp arms cannot do this, and neither can bar clasps engaging an undercut on the side of the tooth away from the denture base. Round clasp forms offer advantages of greater and more universal flexibility, less tooth contact, and better esthetics.[15] Either the round (preferable wrought wire) circumferential clasp (Fig. 8), or the carefully located and properly designed bar clasp (Fig. 9) should be used on all abutment teeth adjacent to free-end denture bases. The reverse clasp is rarely justified for reasons of poor esthetics and excessive tooth coverage. Likewise, the ring clasp also is not justified when used as an unsupported ring. Circumferential clasps may have the appearance of a ring, but they are acceptable only when a supporting strut is used on the side of the tooth opposite the retention (Fig. 10).

STABILIZING COMPONENTS

The stabilizing or bracing components of the partial denture framework are those rigid components that assist in stabilizing the denture against horizontal movement.[7, 10, 15] It is the purpose of all the stabilizing components to distribute stresses equally to all supporting teeth without the abuse of any one tooth. All minor connectors that contact vertical tooth surfaces, and all reciprocal clasp arms must function in this manner. It is necessary that they have sufficient bulk to be rigid, and yet that they present as little bulk to the tongue as possible. This means that they should be confined to interdental embrasures wherever possible. If minor connectors are located on proximal tooth surfaces, they should contact surfaces that have been made parallel to the path of insertion. When cast restorations

are used, these surfaces of the wax patterns should be made parallel to each other on the surveyor prior to casting.

Reciprocal clasp arms must also be rigid and they must be placed above the height of contour of the abutment teeth where they will not be called upon to flex. By their rigidity these clasp arms reciprocate the opposing retentive clasp and they also prevent lateral shifting of the prosthesis under horizontal stresses. If the re-

Fig. 8.

Fig. 9.

Fig. 10.

Fig. 8.—A round, wrought circumferential clasp which, despite its location dictated by tooth contour and length, has advantages of less tooth contact, better esthetics, and greater flexibility not to be found in any other clasp design.

Fig. 9.—A properly used bar clasp engaging a small area of tooth undercut adjacent to the denture base, with a minimum of tooth coverage and maximum flexibility.

Fig. 10.—A circumferential ring clasp engaging a buccal undercut from the distal surface. It is supported by a rigid bar on its reciprocal side. This is, in effect, a minor connector from which the flexible clasp arm originates.

ciprocal clasp is to be placed in the correct position on the tooth, judicious grinding of tooth surfaces is necessary to increase the suprabulge area. Where crown restorations are used, a lingual reciprocal clasp arm may be made a part of the tooth contour by providing a shoulder on the crown upon which the clasp may rest.[13] This permits a wider clasp arm to be used and restores a more nearly normal tooth contour without sacrificing strength and rigidity of the clasp.

The average dental laboratory technicians are not cognizant of the difference between retention and reciprocation. This is apparent because of the frequency of the violations of the principles involved. Dentists must have a clear concept of which clasp arms are reciprocating and which clasp arms are retentive. This is necessary to determine which clasp arm should have a taper and engage an infrabulge area and which should be of uniform diameter for rigidity and lie above the height of contour. Most clasp arms constructed in commercial dental laboratories have the same dimension and taper, with the terminal of each clasp arm engaging an undercut. This procedure is followed because of unclear concepts of design, inadequate designing by the dentist, and the widespread use of tapered plastic ready-made forms. The art of free-hand waxing of clasps is becoming lost to the automaton of the ready-made clasp forms, and the loss of this art is a very real threat to the best quality of dentistry.

RIDGE SUPPORT

The support for the tooth-borne partial denture or the tooth-borne modification space comes entirely from the abutment teeth by means of occlusal rests. Support for any free-end denture base comes primarily from the resilient soft tissues overlying the residual alveolar bone. The occlusal rest support is effective only at the abutment end of the denture base.[6,9,15,16]

The effectiveness of this tissue support is dependent upon four things: the quality of the residual ridge, the total load applied, the accuracy of the denture bases, and the accuracy of the impression registration.

The quality of the ridge cannot be influenced, except to modify it or improve it by surgical intervention. This modification is infrequently advisable and is less frequently done.

We may influence the total occlusal load applied to the residual ridge by reducing the occlusal area through the use of fewer, narrower, and more efficiently shaped denture teeth.

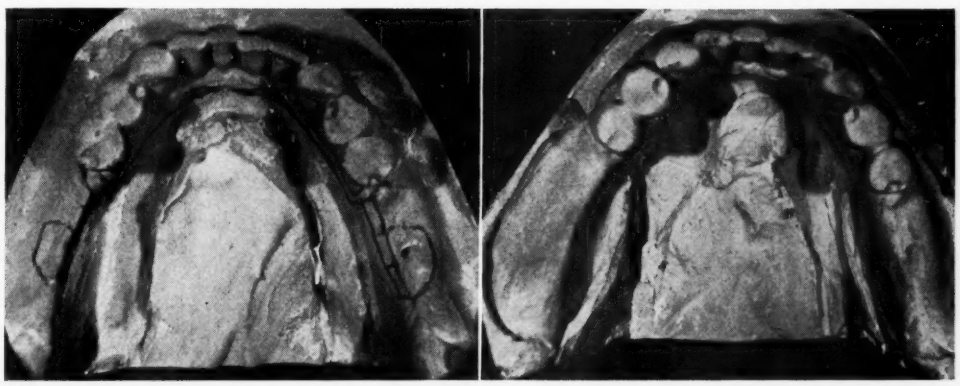
We may influence the accuracy of the denture base by our choice of materials and by the exactness of the processing techniques. Faulty and warped denture bases directly influence the support of partial dentures. Materials and techniques should be used which minimize the possibility of processing errors.

The accuracy of the impression technique is entirely in the hands of the dentist. Maximum tissue coverage for support is the principal objective in any partial denture impression technique. The manner in which it is accomplished is based upon a biologic comprehension of what happens beneath a free-end denture base when an occlusal load is applied.

The partial denture is unique in that its support is derived from both comparatively unyielding abutment teeth and from comparatively yielding or resilient

soft tissues. Resilient tissues, being unable to provide support for the denture base comparable to that offered by the abutment teeth, are displaced by the occlusal load. Only the projections of the underlying residual bone remain to be traumatized by occlusal forces. This problem of support is further complicated by the fact that the patient has natural teeth remaining upon which he may exert far greater force than he would were he completely edentulous. This fact is evidenced by the damage occurring to an edentulous ridge when it is opposed by a few remaining anterior teeth in the opposite arch.

Ridge tissues recorded in their resting, nonfunctioning form are incapable of providing the composite support needed for a denture which derives its support from both the soft tissue and teeth. The ridge tissues are recorded in their resting form by an elastic impression material such as hydrocolloid, rubber base impression materials, impression pastes, or plaster of Paris.



A. *B.*

Fig. 11.—*A*, The anatomic or static form of the edentulous ridge as recorded with a hydrocolloid impression material. *B*, The functional form of the same edentulous ridge as recorded with a wax that is fluid at mouth temperature, such as Kerr's Korecta wax No. 4. The denture base areas of the master cast have been repoured as in Fig. 12.

It is necessary that two factors be taken into consideration in the acceptance of an impression technique for free-end partial dentures. First, the material should record the resilient tissues in their supporting form. Second, the total area covered by the impression should be as great as possible, in order to distribute the load over as large an area as can be tolerated by the patient. This is an application of the principle of the snowshoe. Waxes that are moldable at mouth temperature are the materials of choice for the impression, because they are the only impression materials available that have the combined advantages of controlled displacement of fluid tissues and correctability under functional loading.[15, 16]

Anyone who has had the opportunity of comparing two master casts for the same partially edentulous arch, one having the distal extension areas recorded in their anatomic or resting form (Fig. 11,*A*) the other having the distal extension areas recorded in their functional form (Fig. 11,*B*), has been impressed with the differences of the forms of the two casts. A denture base processed to the functional form is less irregular, and it has generally wider areal coverage than a den-

ture base processed to the anatomic form (the form of the tissues at rest). Moreover, and of far greater significance, a denture base made to anatomic form exhibits less stability under rotating forces than a denture base processed to functional form, and it fails to maintain its occlusal relation with the opposing teeth. Wax biting tests show that occlusion is maintained at a point of equilibrium over a long period of time when the denture base has been made to functional form. In contrast, there is a rapid settling of the denture base when it is made to anatomic form, with an early return of the occlusion to the original natural tooth contact only. Such a denture not only fails to distribute the occlusal load equitably, but it allows rotations which are damaging to the abutment teeth and their investing structures.

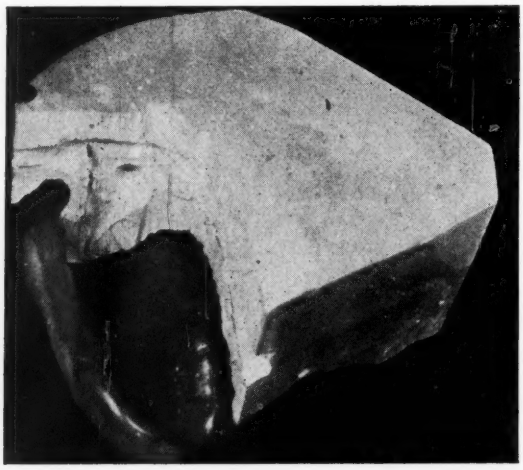


Fig. 12.—The master cast after the ridge portion has been cut away. The cut surfaces are scored for retention, and the wax impression is attached to the remaining part of the cast. The remaining part of the cast is soaked, and the ridge area is repoured with a new mix of stone.

Unfortunately, dental laboratory technicians have had no inclination to accept the correction of the master cast to the supporting form of the ridge as an essential part of partial denture design (Fig. 12). This is further evidence of a lack of biologic comprehension. It is, therefore, the dentists' responsibility to perform this and certain necessary laboratory procedures if the partial denture is to be more than a mechanical device.

In the lower arch, the resiliency of the ridge tissues makes the functional form impression technique the method of choice. In the upper arch, however, where the ridge tissues are generally more firm, and the support for the denture base is obtained from both the ridge and the palatal tissues, the wax impression is not always used. Where wide palatal coverage is to be incorporated into the partial denture design, an alginate or rubber base impression in an individual tray is sometimes acceptable.

For this procedure, an acrylic resin tray is made by the sprinkling method. The tray is made on the study cast, which is relieved with three thicknesses of wet, sheet asbestos. Occlusal stops on either side of the cast may be left exposed if

desired. A wire handle may be added to the tray, or a loop of wire in the palate may be used for convenience in removal. The tray is trimmed just short of the reflections, border molded in modeling plastic, wax, or an impression paste, and then perforated with a bi-bevel drill. This tray is used for the final impression. The resulting master cast is acceptable for the upper free-end partial denture because of the added support obtained by full palatal coverage.

INDIRECT RETAINERS

Any strut placed anterior to the fulcrum line is mistakenly considered to be an indirect retainer. An indirect retainer can function only to assist in preventing the rotational movement of a free-end denture base away from the tissues when the indirect retainer is placed as far anteriorly from the fulcrum line as adequate tooth support permits.[15, 17] It must be placed in a prepared rest in an abutment tooth that is capable of withstanding the stresses placed upon it (Fig. 13). An indirect

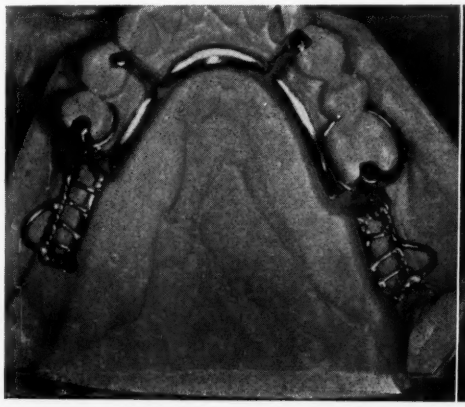


Fig. 13.

Fig. 14.

Fig. 13.—Indirect retainers are placed anterior to the fulcrum line on the mesial marginal ridge of each first premolar. These have been prepared to receive the auxiliary occlusal rests.

Fig. 14.—A lingual plate properly designed and located. Note the upper border just above the cingula, the lingual contour, and the occlusal rest support at either end of the plate. The half-pear, cross-section shape of the lingual bar may still be identified; the thin lingual plate is merely an addition to the lingual bar major connector.

retainer cannot function correctly on an inclined tooth surface, nor can a lower incisor tooth be used for this purpose. Either canine or premolar teeth must be used for this purpose, and the rest seats must be prepared in those teeth as carefully as the preparation for any other occlusal rest. Where canine teeth are used, incisal rests or cingulum rests are acceptable for indirect retainers, provided a definite seat can be obtained.

It should be remembered also that indirect retainers serve a second purpose in partial denture design. This purpose is that of occlusal rest support for major connectors. A long lingual bar or an anterior palatal bar is thereby prevented from settling into the tissues. Indeed, even in the absence of a need for indirect retention, such auxiliary support is sometimes indicated.

It should be remembered also that, contrary to common usage, a secondary lingual (Kennedy) bar or a lingual plate does not in itself act as an indirect re-

tainer. Resting on inclined tooth surfaces as they do, they serve more as orthodontic appliances than as support for partial dentures. Terminal rests at each end of these lingual plates should be used to stabilize the dentures and prevent movement of the teeth contacted. If such rests are used, they alone are the indirect retainers, and they function equally well without the added bar or plate.

The use of a lingual plate is indicated where the lower anterior teeth are subject to calculus formation or are weakened by periodontal disease (Fig. 14). Calculus may then form on the plate instead of forming on the teeth. Experience with the lingual plate has shown that the underlying tissues do remain healthy and that there are no harmful effects to the tissues from the metallic coverage.

However, one precaution must be taken. Adequate relief must be provided where the bar or plate crosses the gingival margins and the adjacent gingivae. This should be accomplished by using at least a 0.002 gauge tin-foil blockout in these areas, in addition to a wax blockout of the gingival crevice.

It does not seem that there are any advantages to be had from the use of the Kennedy bar that are not enhanced by the use of a lingual plate. There are times, however, when the lingual plate would show through interproximal embrasures of the teeth, and, for esthetic reasons, the Kennedy bar would be preferred. The decision as to when to use the Kennedy bar or the lingual plate and its design should be made by the dentist rather than by the laboratory technician and should be clearly indicated by the dentist on the cast.

BLOCKOUT OF UNDERCUTS

The decision as to where to use blockout wax should be made by the dentist from his survey of the master cast. Twenty-eight gauge wax, in addition to a wax blockout of the tissue undercuts, is usually sufficient to relieve the lingual bar connectors. Two or three-thousandths gauge tin foil should be used over all gingival crossings, in addition to blocking out the gingival crevice. Any less relief than this will cause tissue impingement when the appliance settles. More relief than this will leave an unnecessary and objectionable space between the framework and the underlying tissues.

Where bar clasps are used, the blockout for the clasp arms should be sufficient only to prevent tissue impingement. However, excessive blockout is usually used with a resulting annoyance to the tongue and cheek and with the sacrifice of esthetics. In many instances, where tissue undercuts exist, the bar clasp is contraindicated, and it should not be used at all.

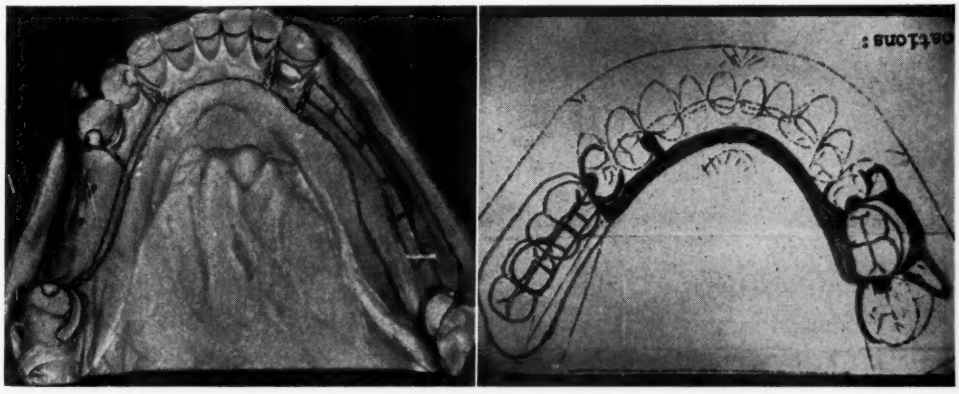
All proximal tooth surfaces which underlie minor connectors, especially those at the point of origin of the occlusal rests and clasp arms, should be as nearly parallel to the path of insertion of the appliance as possible. This is accomplished either by disking these surfaces or by paralleling the wax patterns of the cast restorations. The latter should be done on the surveyor whenever possible, rather than attempting to parallel the finished restorations in the mouth. At the same time, tooth contours which provide for the location of retentive and stabilizing clasp arms should be established.

If the dentist has made no provision for parallel tooth surfaces, carelessness on the part of the laboratory technician in accomplishing the blockout can do little

harm, for in such a case too much relief is better than too little. On the other hand, if the dentist or the laboratory technician has provided for parallel guiding planes on the proximal tooth surfaces, those guiding planes should not be obliterated by a careless blockout. Having determined the path of insertion for the partial denture in advance, the blockout must be so paralleled on the surveyor that guiding planes are left exposed and effective. The only permissible relief over these areas is a tin-foil relief to prevent cast abrasion during the surveying and the blockout procedures.

SUMMARY

I have attempted to excuse the shortcomings of the commercial dental laboratory by pointing out the responsibilities of the dentist for biologic partial denture design and his frequent failure to provide the laboratory technician with casts of properly prepared mouths and adequate prescriptions for him to follow. By "prescription" I am referring to penciled outlines (Fig. 15,*A*), diagrams (Fig. 15,*B*), and written instructions prepared by the dentist for the dental technician.[13] Now I must also make a statement regarding the responsibilities of the commercial dental laboratory in the hope that they, too, may find some motivation for improving their services.



A. *B.*

Fig. 15.—*A*, The outline form of the denture framework has been carefully drawn in pencil on the surveyed master cast. The laboratory technician has only to duplicate this design in his casting so that when the casting is placed on the master cast it matches the penciled outline. *B*, The framework design is drawn on a chart with colored pencils. Labels and written instructions are used to supply the specific details.

In the average commercial dental laboratory today, mass production is an economic necessity. It is augmented by the use of stereotyped designs and plastic pattern forms. Added to this, the salary level of the skilled dental laboratory technician is not high by today's economic standards, and the training facilities for dental laboratory technicians are woefully inadequate. In many areas, adequate training facilities are nonexistent. However, despite this, quality partial denture and mouth rehabilitation service is needed now more than ever before. Teeth that would have been lost in the past by periodontal disease, caries, or by pulpal involvement are being saved now by the thousands. Increased life expectancy has placed

us on the threshold of geriatric dentistry, with its many implications and challenges for the future dental care of an aging population.[18]

Human mouths are not stereotyped, and neither are the problems in mouth reconstruction. Stereotyped partial denture service must be replaced with individualized treatment planning and rehabilitation service.[19] Dentists must do more than make a single impression, send it to the commercial dental laboratory, and receive a finished appliance to be inserted in the mouth.

Also, it seems a little bit incongruous to spend a great deal of time and effort on elaborate research in the testing of some of the clinical principles in partial denture design, when these very principles are being so flagrantly violated by those responsible for their clinical application.

If training facilities and increased salary standards for dental laboratory technicians are needed, then let the dental profession have the courage and the integrity to lead the way toward their improvement. But also, let the profession demand standards of individualized service from the commercial dental laboratory in keeping with competent and informed leadership.

REFERENCES

1. DeVan, M. M.: The Nature of the Partial Denture Foundation: Suggestions for Its Preservation, J. Pros. Den. **2**:210-218, 1952.
2. Christensen, George: Partial Dentures—A Benefit or a Menace? Australian J. Den. **49**:102-107, 1945.
3. Wright, W. H.: Partial Denture Prosthesis: A Preventative Oral Health Service, J.A.D.A. **43**:163-168, 1951.
4. Loos, Anthony: Bio-physiological Principles in the Construction of Partial Dentures, Brit. D. J. **88**:61-68, 1950.
5. Steffel, V. L.: Fundamental Principles Involved in Partial Denture Designs—With Special Reference to Equalization of Tooth and Tissue Support, D. J. Australia **23**:68-77, 1951.
6. Lammie, G. A., and Osborne, John: The Bilateral Free-end Saddle Lower Denture, J. Pros. Den. **4**:640-652, 1954.
7. Frechette, A. R.: Partial Denture Planning With Special Reference to Stress Distribution, J. Pros. Den. **1**:710-724, 1951.
8. Hindels, George W.: Stress Analysis in Distal Extension Partial Dentures, J. Pros. Den. **7**:197-205, 1957.
9. McCracken, William L.: A Comparison of Tooth-borne and Tooth-tissue-borne Removable Partial Dentures, J. Pros. Den. **3**:375-381, 1953.
10. Steffel, V. L.: Fundamental Principles Involved in Partial Denture Design, J.A.D.A. **42**:534-544, 1951.
11. Applegate, Oliver C., and Nissle, R. O.: Keeping the Partial Denture in Harmony With Biologic Limitations, J.A.D.A. **43**:409-419, 1951.
12. Perry, Chester, and Applegate, S. G.: Occlusal Rest—An Important Part of a Partial Denture, J. Mich. D. Soc. **13**:9-13, 1947.
13. McCracken, William L.: Mouth Preparations for Partial Dentures, J. Pros. Den. **6**:39-52, 1956.
14. Roach, F. E.: Roach Bar Clasp, D. Survey **21**:249, 1945.
15. Applegate, Oliver C.: Essentials of Removable Partial Denture Prosthesis, Philadelphia, 1954, W. B. Saunders Co.
16. Applegate, Oliver C.: The Partial Denture Base, J. Pros. Den. **5**:636-648, 1955.
17. MacKinnon, K. P.: Indirect Retention in Partial Denture Construction, D. J. Australia **27**:221-225, 1955.
18. Applegate, Oliver C.: Conditions Which May Influence the Choice of Partial or Complete Denture Service, J. Pros. Den. **7**:182-196, 1957.
19. Craddock, F. W.: Partial Dentures in Oral Rehabilitation, New Zealand D. J. **49**:6-13, 1953.

University of Alabama, School of Dentistry
1919 S. 7th Ave.
Birmingham 3, Ala.

INTERNAL ATTACHMENT FOR FIXED REMOVABLE PARTIAL DENTURES

IRWIN J. PLOTNICK, D.D.S.
Glenside, Pa.

NATURAL UNDERCUTS IN AN occlusogingival direction occurring on the mesial and distal surfaces of teeth are a means for securing an ideal type of retention for removable partial dentures. The use of these undercuts in a controlled scientific method is the basis of the technique to be described.

In the edentulous space bounded by abutment teeth, the distance between the occlusal surfaces is shorter than the distance between the gingival margins (Fig. 1). This is due to the mesial inclination of the mesial surface of the molar, and the distal inclination of the distal surface of the bicuspid in their gingival thirds. When viewed from the occlusal surface, the distance between the center points of the teeth is shorter than the distances at the lingual and buccal aspects, respectively (Fig. 1). This is due to the convexity of the proximal surfaces of the teeth.

Provided these distances remain constant, a prosthesis fitting this space precisely could not move in an occlusal, buccal, or lingual direction. With occlusal rests on both teeth, the prosthesis could not move in the gingival direction. The restoration would be held firmly in position.

To fill this edentulous space exactly, the prosthetic restoration must have three inherent characteristics to remain functional and not damage the natural structures: (1) from one occlusal rest to the other occlusal rest the restoration must be one continuous unit to resist positive masticating forces; (2) the restoration must be seated and withdrawn without causing pressure on the abutment teeth; and (3) the restoration must be held firmly in position unless it is removed intentionally.

THE M-D LOCK

The M-D Lock consists of five parts (Fig. 2). The over-all height of the device in the closed position is 3.25 mm., the width is 2.50 mm. the length in the closed position is 7.75 mm. and in the open position is 5.75 mm.

When the plunger of the M-D Lock is pushed down, it will cause the slide to move 2.0 mm. (Fig. 2,*A*). When the plunger is down, the slide cannot move in any direction (Fig. 2,*B*). When the plunger is pulled back up, the slide is free to slide back into the housing. The retaining pin prevents the slide from coming out of the housing and works in harmony with the plunger in the closed position. The connecting rod provides a "handle" for lifting up the plunger to the open position and also connects the tooth to the plunger.

Received for publication March 22, 1957; revised by the author Aug. 7, 1957.

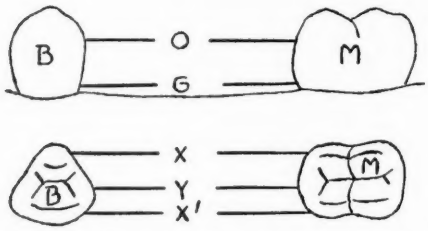


Fig. 1.—*Above,* Buccal view; *B,* bicuspid; *M,* molar. The distance between the teeth is less at *O* than at *G. Below,* Occlusal view. The distance between the teeth is less at *Y* than at *X* or *X¹.*

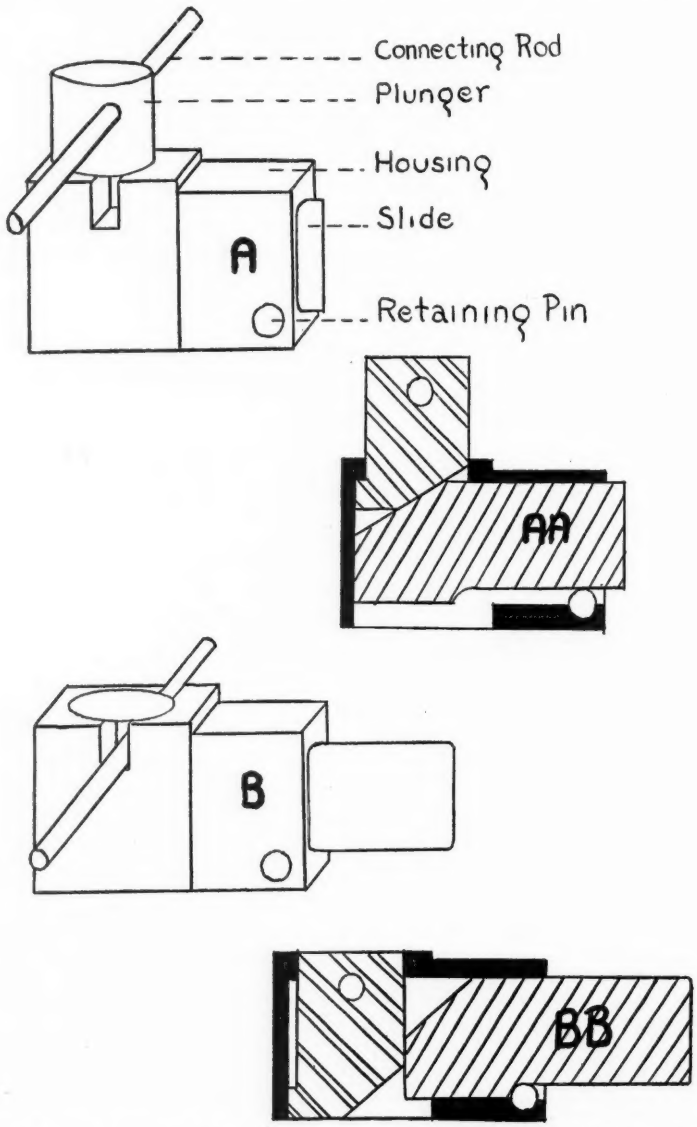
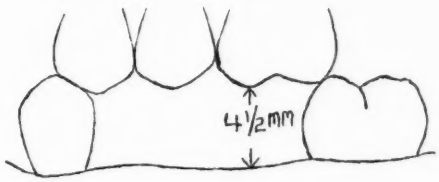


Fig. 2.—*A* and *AA,* The M-D Lock in the open position. *B* and *BB,* The M-D Lock in the closed position.

TECHNIQUE OF CONSTRUCTION

Study casts are made to determine that the following conditions are present: (1) there must be a minimum of 4.5 mm. from the mucous membrane of the edentulous area to the teeth of the opposing arch (Fig. 3); (2) the undercuts between the abutment teeth must meet the requirements illustrated in Fig. 1. The total undercut in a horizontal direction must not be greater than the 2 mm. movement of the M-D Lock. This is determined by mounting the study cast on a surveyor, and tilting the cast so one tooth-surface bounding the edentulous space is parallel with the survey rod. Maintaining this angle, the rod is placed into contact with the tooth surface at the opposite end of the edentulous space (Fig. 4). By measuring the distance from the rod to the mesial surface of the tooth at the gingival margin, the total undercut is determined. This also determines the path

Fig. 3.



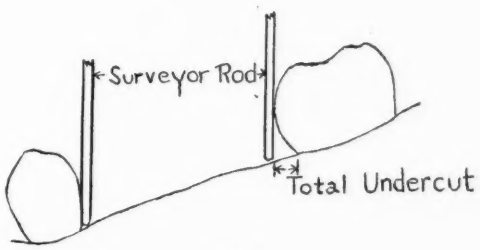


Fig. 4.

Fig. 3.—The minimum space requirement in a vertical direction. This measurement is made only in the area where the M-D Lock will be placed.
Fig. 4.—Survey to determine the amounts of mesiodistal undercut.

of insertion. (The cast may be tilted anteriorly so the mesial surface of the molar is parellel to the path of insertion, or it may be tilted posterioly. The side of the tooth at the opposite end of the edentulous area from the M-D Lock determines which path of insertion is to be used.) Usually, the undercut will range from 0.75 to 1.5 mm. If the undercut is too great, it may be reduced by reshaping the enamel contour of the abutment teeth.

For the purpose of this example and explanation, 1.5 mm. is used as the total undercut.

OCCLUSAL RESTS

Occlusal rests are prepared on the abutment teeth with a dovetail shape (Fig. 5). The purpose of the dovetail shape is to create an added cause for pressure, during function, to tend to tilt the teeth toward the edentulous space. Since

the partial denture will fit the edentulous space exactly, this tilting pressure will be nullified by the support of the partial denture, and the effect will be to maintain the same abutment teeth in the same relationship they are in when the impression is made.

An accurate impression of the arch to be restored and one of the opposite arch are made with the rubber base impression material. All of the necessary casts may be obtained from these impressions. If other impression materials are used, the master cast must be duplicated. The centric relation and the color of the teeth are recorded.

Fig. 5.—The occlusal rests are dovetail-shaped and are confined entirely within the enamel. The floor of the rest seats is inclined toward the center of the tooth.

THE WAX PATTERN

The first cast is made in a refractory investment material. One sheet of 30-gauge casting wax is placed over the edentulous area of this cast. This is the minimum thickness of wax to be used, and regular inlay wax is added where required.

A standard-type pontic tooth is now set in position in the edentulous area in the usual manner. The space abutting the bicuspid abutment, including the occlusal rest, is completely filled with wax.

The M-D Lock, in closed position, is lubricated with a separating medium. It is then placed upon the 30-gauge wax and is positioned so that the end of the slide is a minimum of 1.0 mm. from the molar abutment and is slightly lingual to a buccolingual center of the teeth (Fig. 6).

The M-D Lock is now adjusted to the open position. Two carbon rods, 0.036 inches in diameter, are placed alongside the M-D lock, one on each side, and at an opposite anteroposterior five degree angle with the plunger. The wax-up for the M-D Lock seat is then completed (Fig. 7).

Following this, the opposite occlusal rest and the top part of the "T" clasp are waxed in (Fig. 8). The underside of the occlusal rest must not engage any portion of the undercut on the mesial surface of the molar abutment. The contour of the base is finished to the outline of the molar pontic. The wax is smoothed, making sure that there are no undercuts in an occlusogingival direction. The bicuspid pontic is removed and, with the slide pushed completely in, the M-D Lock is removed. The finished wax-up is shown in Fig. 9.

The pattern is sprued for casting. After the casting is made, there are three parts: the main base, the molar occlusal rest, and the top part of the "T" clasp. These parts are now removed from their respective sprues, shaped with stones, and smoothed with a rubber wheel.

SOLDERING ASSEMBLY

The second cast is poured in soldering investment and the base portion is seated upon this cast. Then the M-D Lock is placed in its seat on the base. It should fit the same as it did in the wax pattern. However, a slight discrepancy will in no way affect the final fit. Now the top part of the "T" clasp is placed alongside the molar abutment and this must fit the cast exactly. The M-D Lock is now placed in closed position. If the casting interferes with the full closure of the Lock, the casting must be ground until the Lock is fully closed, and approximately 0.5 mm. of space exists between the slide and the casting (Fig. 10). Wax is flowed in this space, and the casting is covered with soldering investment, so that the slide and casting may be soldered. This forms the complete "T" clasp (Fig. 11).

After soldering, the assembly is cleaned and ground so as to enable the slide to be moved completely back into the housing.

The casting is now seated on the third and final cast which is made of a hard stone. The molar occlusal rest is placed in position and attached with sticky wax to the M-D Lock and to the walls of the M-D Lock seat of the saddle. The plunger is then lifted, the slide is teased back, and the casting is removed from the cast. With an explorer, the retaining pin is removed through the holes in the walls of the base, and the slide is withdrawn. The assembly is invested for soldering the occlusal rest to the M-D Lock and the walls of the saddle to the M-D Lock and occlusal rest (Fig. 12). This will unite the entire denture into one continuous piece with the exception of the slide, which must move into and out of the housing.

MECHANICS OF RETENTION

The means by which the partial denture utilizes the principle for retention in the dental arch (Fig. 1) can now be seen. To seat the appliance, the plunger is in the open position, and the slide is within the housing. Since the slide moves 2 mm. and the total undercut area is 1.5 mm., the partial denture, by following the path of insertion (which is parallel and in contact with the distal surface of the bicuspid abutment), may be seated on the cast. The plunger is forced down. This action will extend the slide 2 mm. firmly locking the "T" clasp against the mesial surface of the molar. The partial denture fits the edentulous space exactly. No pressure is exerted in seating and, after seating, there is no pressure in the rest position.

To remove, the plunger is lifted, then the entire restoration is lifted occlusally, along the path of insertion. This will readily tease the slide back into the housing as it glides along the inclined mesial surface of the molar abutment. In effect, the partial denture expands and contracts 2 mm. in length below the level of the occlusal rests.

PLASTIC CROWN COVER

The M-D Lock portion of the restoration is covered with either a plastic or gold crown. The use of a plastic crown will be described here, but there is very little difference in technique other than in the method applying to each material of which the covering crowns may be made.

The partial denture is polished, and the carbon rods are ground out of the casting by using a number ½ round bur. Into these holes, 0.036 inch gold wrought

Fig. 6.

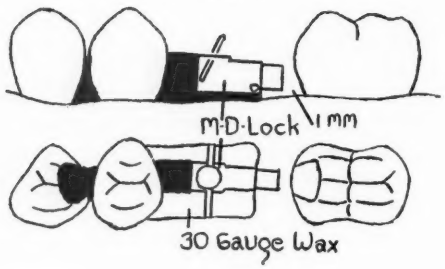
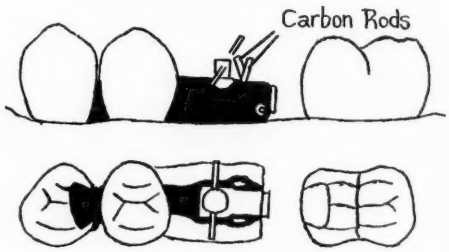


Fig. 7.



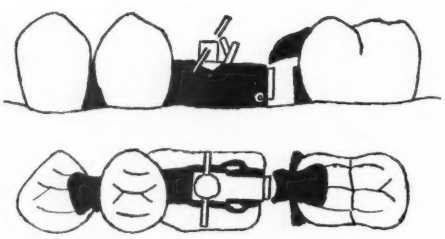


Fig. 8.

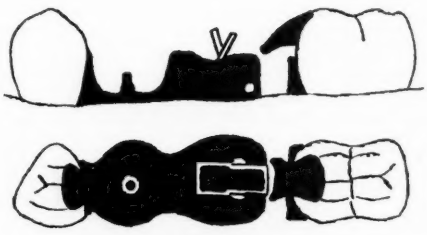


Fig. 9.

Fig. 6.—The wax between the pontic and M-D Lock is made level with the Lock and must not contain any undercut.

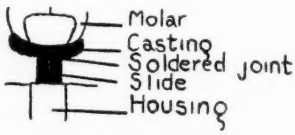
Fig. 7.—The two carbon rods should straddle the entire height of the M-D Lock. Note that a small hole is left on both sides through which the retaining pin can be removed.

Fig. 8.—The molar occlusal rest approaches the M-D Lock as closely as possible without preventing the vertical removal of the Lock. The "T" clasp is extended buccally and lingually so that it may be held in position during soldering. It is reduced later the same width as the occlusal rest.

Fig. 9.—The completed wax pattern. A minimum of four sprues are used, one in the bicuspid area, the second to the M-D Lock seat, and the remaining two to the molar occlusal rest and "T" clasp.

Fig. 10.

Fig. 11.



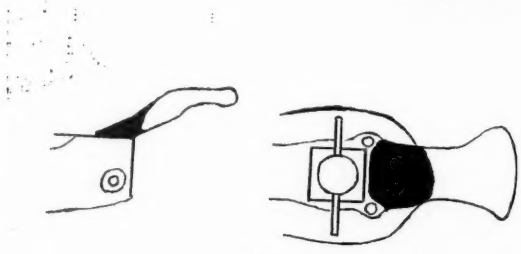


Fig. 12.

Fig. 10.—Where the total undercut area is small, an alternative to thinning the "T" clasp is to grind off the end of the slide. This will reduce the amount of effective movement but will not otherwise affect the M-D Lock.

Fig. 11.—The relations of the various parts of the attachment.

Fig. 12.—The slide is removed so as to facilitate the soldering of the molar rest and to eliminate the possibility of the solder reaching the slide.

wire is placed. The wires are bent to about a 90 degree angle so as to be locked into the plastic resin cover (Fig. 13).

With the connecting rod in place, the area is lubricated and the two wires are joined together with sticky wax. White wax is then used to finish the contour of the crown. The finished wax crown is shown in Fig. 14.

When the wax crown is completed, the connecting rod is withdrawn and the crown is removed. The connecting rod is now reinserted through the holes in the crown and allowed to extend buccally and lingually from the crown. The crown is then invested for processing into plastic (Fig. 15).

Fig. 13.

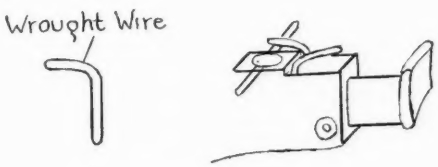
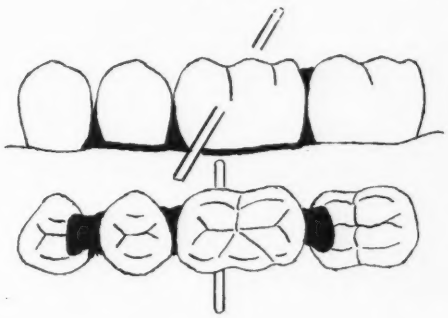


Fig. 14.



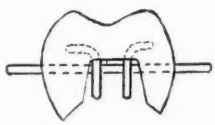


Fig. 15.

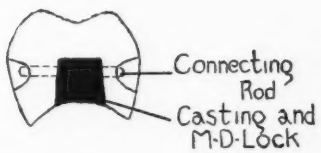


Fig. 16.

Fig. 13.—Wires to lock the covering crown in place. The bottom tips of the wires are made round to permit their insertion in unison.

Fig. 14.—The wax pattern of the covering crown with the connecting rod in place. Do not attempt to test the M-D Lock with the wax crown as it will cause distortion of the wax.

Fig. 15.—A proximal view of the wax pattern of the crown. The connecting rod is inserted so as to insure the correct location of the holes.

Fig. 16.—The connecting rod is cut short so as to be completely within the contour of the crown, and the holes are filled with acrylic resin.

After the plastic crown is removed from the stone mold, the connecting rod is removed with warmed pliers, and the inner and outer surfaces are thoroughly cleansed. With a small bur or stone, the lingual and buccal (connecting rod) holes are slightly enlarged in diameter. The crown is then placed over the M-D Lock and adjusted to its correct seating position (Fig. 16).

The crown is removed and the retaining pinholes in the base casting are filled with a cement or acrylic resin material. The crown is then reseated, the connecting rod inserted, and the holes of the crown are filled with a fast-setting acrylic resin (Figs. 17 and 18).

MODIFICATIONS OF DESIGN

In cases in which the teeth of the opposing arch leave a minimum of space on the occlusal surface, a gold veneer crown may be used to cover the M-D Lock. In

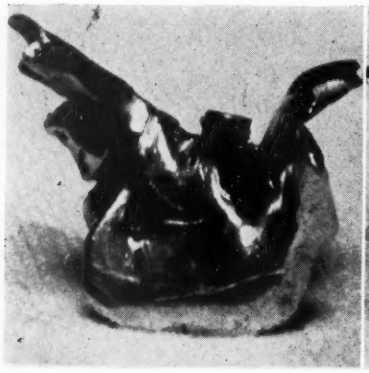


Fig. 17.

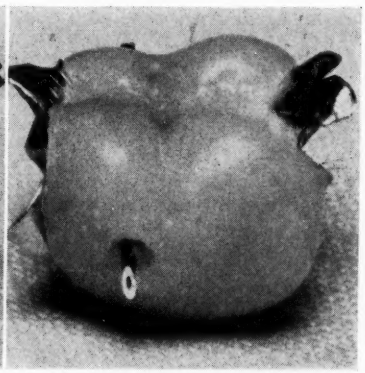


Fig. 18.

Fig. 17.—The base casting and the M-D Lock complete.

Fig. 18.—The completed restoration. An acrylic resin crown covers the attachment and the base casting.

Fig. 19.

Fig. 20.

Fig. 21.

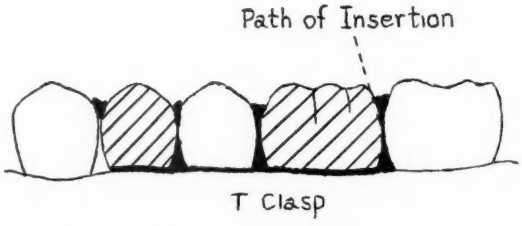


Fig. 19.—A rigid clasp arm is extended, without engaging any undercuts, to the opposite side of an abutment tooth, thereby providing stability for a mobile tooth.

Fig. 20.—Where the articulation permits, additional stability can be obtained by extending the occlusal rest across the occlusal surface of the abutment tooth and onto an additional adjacent tooth.

Fig. 21.—With crown preparations on the abutment teeth, various attachments into the crowns can be devised. When artificial teeth are interposed with natural teeth, a double locking is obtained. The first is by the edentulous space being fitted exactly, and the second is by the interposed natural tooth being grasped by the "T" clasp and adjacent base frame.

this case, the pins are left straight and are soldered later to the gold crown. The technique can be adapted to make it usable in many prosthetic situations. The designs shown in Figs. 19, 20, and 21 are examples. The methods shown should permit bilateral as well as unilateral case designs.

SUMMARY

1. A removable partial denture has been described which is easily inserted and removed by the patient and causes no force on the abutment teeth in either direction.

2. There are no mechanical unions in the denture to wear or distort under pressure.

3. The occlusal rests prevent movement in a gingival direction during function.

4. The M-D Lock is maintained in the closed position by the occlusion with the opposing teeth.

5. Food traps between the abutment teeth and the denture are eliminated.

6. The restoration has good esthetic qualities and is comfortable to the tongue.

7. The preparations for abutment crowns do not need to be made parallel. The preparations can be made conservatively so the pulps will not be endangered. No space for internal attachments is necessary.

This technique combines most of the advantages of removable and fixed partial dentures, while their disadvantages are eliminated or greatly minimized.

124 S. Easton Rd.
Glenside, Pa.

A METHOD FOR REGISTERING OCCLUSION IN SEMIEDENTULOUS MOUTHS

JOHN H. EMMERT, D.D.S.*
Western Reserve University, School of Dentistry, Cleveland, Ohio

THE PROBLEMS OF PROPERLY relating master casts for restorative dentistry often involve more guesswork than science. Almost all techniques that use indirect casts require an interocclusal record of some type to relate them properly. This is not particularly difficult as long as a full complement of teeth is present in the mouth. Most all crown and bridge techniques make use of interocclusal records of some sort. The hydrocolloids and the newer plastic impression materials for multiple inlay restorations make it important to relate accurately the master casts used in these techniques. The materials commonly used for interocclusal records are baseplate wax or beeswax. The material is trimmed to cover the occlusal portions of the teeth and softened. The patient is then instructed to close into the wax, closing until the teeth are in contact, or he is asked to bring the teeth together. The wax is then removed from the mouth and examined. If the teeth appear to have been in contact, it is concluded that the record is accurate. The interocclusal record and the master casts are sent to the laboratory. The technician is asked to mount the casts and to construct an appliance on them, assuming they are correctly related. Many laboratory technicians will ignore these wax interocclusal records and mount the casts arbitrarily. Some dentists who do their own laboratory work use wax interocclusal records only as a last resort, and many times they would rather guess at the relationship than risk using a wax record.

Variations of the wax technique are used by placing a softened piece of baseplate wax on the left side, and the dentist is supposedly able to tell when the occlusion is correct by checking the way the teeth occlude on the right side and vice versa. This method is no more accurate than the first and may be less accurate. This type of record can be moved into several positions that will appear to indicate a correct relationship. Frequently, master casts placed in these wax interocclusal records will have a decided anteroposterior rock. This must be compensated for arbitrarily by the technician.

When occlusion rims are used as an aid in registering jaw relationship for removable partial dentures, another error is brought into the technique. As the patient closes into the wax, the tissue under the occlusion rim is displaced. When the occlusion rim is returned to the cast, the occlusal vertical dimension will be open by the amount the tissue was displaced. Thus, with posterior teeth being supplied, the appliance might be constructed with the occlusal vertical dimension open one-eighth of an inch or more.

Received for publication April 22, 1957.
*Assistant Professor of Crown and Bridge Dentistry.

Dentures with free-end bases, therefore, may be in supraocclusion, but this may not be noticeable when the dentures are first inserted. The free-end bases will displace the soft tissue almost as much as the occlusion rim did. The denture will be uncomfortable on the crest of the ridge and will require relief later. Usually, the dentist decides there was something wrong with the impression and begins relieving the denture bases. When this is not successful, the occlusion is adjusted as a last resort.

TESTING INSTRUMENT

A special instrument was devised in order to check the accuracy of interocclusal records. This instrument is a jig, consisting of a base, to which a lower cast could be attached, and a vertical back continuous with the base. The back piece had a movable section in a vertical direction to which was attached a fixed stylus suspended over the lower cast. Another stylus was attached to the upper cast when it was in correct position on the lower cast. In this manner, the second stylus could be aligned perfectly with the aforementioned fixed stylus (Fig. 1). Thus, when interocclusal records were introduced between the teeth of the casts, the alignment of these pointers gave an indication as to the accuracy of the records.

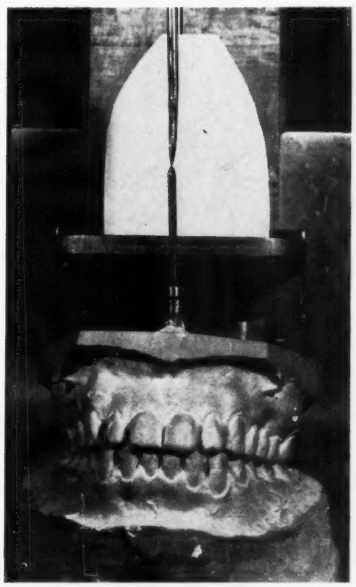


Fig. 1.—Casts mounted on a specially designed instrument for testing interocclusal records. The casts are related by fitting them together in centric occlusion.

INTEROCCLUSAL RECORDS

A series of wax interocclusal records was made to check their accuracy. These records were made in (1) baseplate wax, and (2) Aluwax with cloth reinforcement.

The patient selected for these test records was one with a normal complement of teeth and a near normal occlusion (Fig. 1). Master casts of the patient

were mounted on the instrument described in centric occlusion. The stylus attached to the upper cast and the one mounted on the base were placed directly over each other. The interocclusal records from the patient were then used to remount the upper cast (Fig. 2). Although some were close, none gave the same relationship as that established by simply placing the casts together in centric occlusion (Figs. 3, 4, and 5). It is significant that these casts were of a dentist's mouth and that he made the interocclusal records himself.

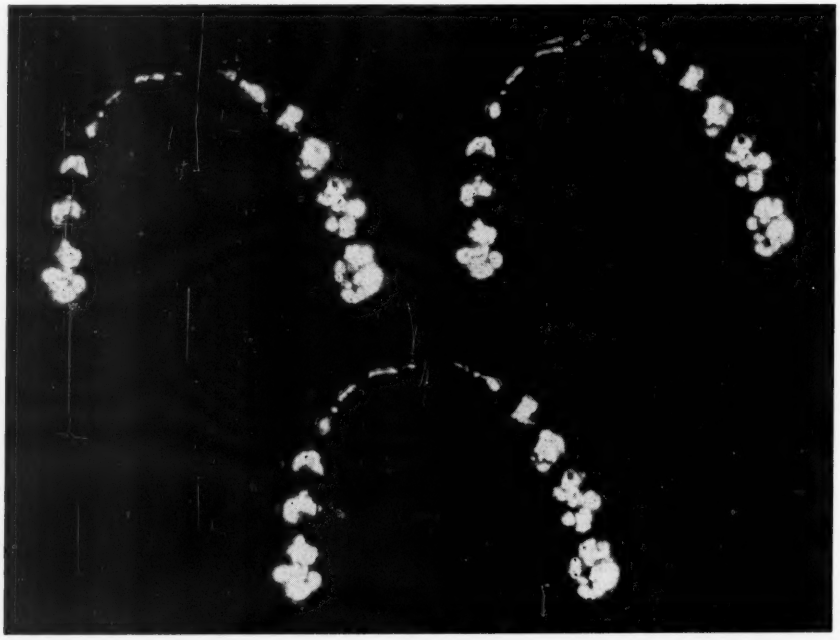


Fig. 2.—Three wax interocclusal records made by the same patient as in Fig 1. Note that they all look alike.

The difficulty in making a wax interocclusal record may be explained by the fact that the patient tends to shift the position of the mandible to compensate for the resistance he meets in closing through the wax. As resistance is encountered, he tends to shift the jaws to bring the cusps of the teeth in position to tear or grind the material in the mouth. In the final stages of closing, the wax becomes so thin that it offers resistance and cannot be completely displaced. This causes the teeth themselves to move. The shift from left to right, or vice versa, is easily demonstrated on the device described. Therefore, in order to produce accurate jaw relation records, the material used should offer no resistance when the patient closes, yet it should be firm enough when it hardens to make an unyielding matrix to place the casts together accurately.

ZINC OXIDE AND EUGENOL RECORDS

A method has been devised that permits this accuracy. This method involves the use of the Jones Bite Frame* (Fig. 6) used with a zinc oxide and

*Designed and manufactured by Russell Jones, Cleveland, Ohio.

eugenol paste. This paste is extremely soft and it sets hard enough to mount the casts accurately. It is not brittle and can be trimmed without crumbling. The frame is first adjusted on the study casts of the lower teeth so that space is left

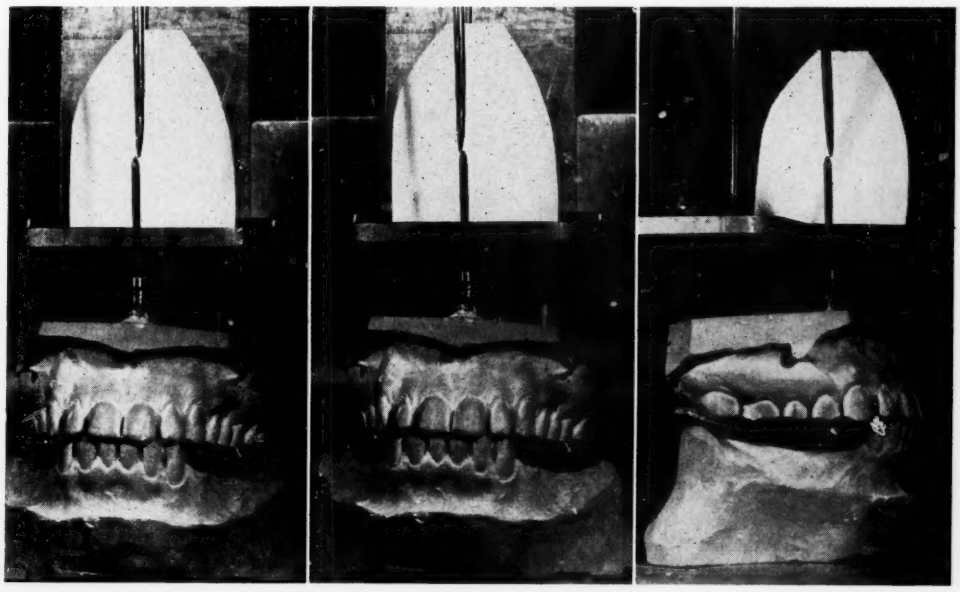


Fig. 3. Fig. 4. Fig. 5.

Figs. 3, 4, and 5.—The pointers indicate the variations in the three wax interocclusal records seen in Fig. 2.

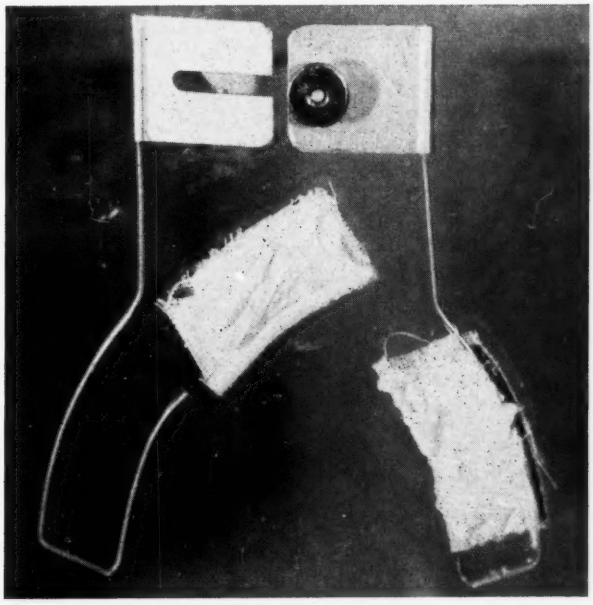


Fig. 6.—The adjustable Bite Frame used to facilitate the placing of the zinc oxide and eugenol paste in the mouth for making an interocclusal record.

distal to the last tooth and so that the frame clears the occlusal portion of the teeth. It must not impinge upon the soft tissue. The frame is supplied with pieces of gauze that can be fastened to it. A plastic tube is attached to one side of the gauze, and this slides over the lingual extension of the frame. The free side of the gauze is tacked to the buccal wing of the frame with a strip of soft utility wax. There should be space between the distal end of the gauze and the frame so that the dentist can see to place it on the last tooth.

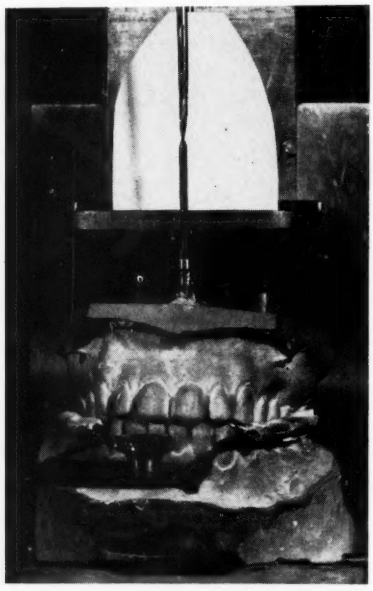


Fig. 7.—The pointers are correctly aligned when the interocclusal record is made with a zinc oxide and eugenol paste which offers no resistance to closure.

A mix of zinc oxide and eugenol paste is made heavy enough to allow a mass of the material to be placed on the gauze without running off. Both sides of the gauze are coated, and the frame is inserted in the mouth. The posterior portion of the frame should lie distal to the occluding teeth. The patient is instructed to close the teeth together, while the dentist holds the frame at the level of the occlusal plane of the teeth. When the teeth are in centric occlusion, the patient is asked to close his lips and hold the instrument in place while the paste is setting. After the paste has set, the frame is removed from the mouth, and the interocclusal record is inspected to see that the teeth were in contact. Holes in the record represent places where the teeth were in contact, and these are visible when the material is held up to the light. The gauze, with the record attached, is removed from the frame to prevent interference with the casts. This is done by freeing the gauze from the wax tacked to the buccal wing of the frame and slipping the tube from the lingual extension. The casts are placed firmly in the interocclusal records, making sure that they are completely seated. It may be possible that the casts will not seat correctly in the interocclusal record because: (1) the interocclusal record is overextended in a location that displaces the soft

tissue; or, (2) the interocclusal record extends into undercuts not duplicated on the casts. If either of these situations exist, it is corrected, and the process is repeated. Records produced by the above technique were checked for accuracy in the same manner as described for the wax interocclusal records. All the results were perfect when this method was used. This was the only method used that would permit the correct mounting of the study casts (Fig. 7).

Wax interocclusal records are used for relating dies for the waxing of crowns and inlays. If wax is used for this purpose, the contact points are always in doubt because of the inaccuracy of the wax; also, the dies are difficult to seat in the record. If copper bands, containing modeling compound or wax, are forced over the teeth to aid in placing dies, the prepared teeth may be wedged apart so they will not be in their true relationship to each other. Dies may be mounted correctly for this technique by using one-half of the Bite Frame. For this purpose, a generous amount of zinc oxide and eugenol paste is used on the upper and lower side of the gauze. When the interocclusal record has been removed from the teeth, it will be a reasonably accurate impression of both the upper and lower teeth, and the dies can be mounted in the impression in their correct relationship.

When one arch is edentulous on one side, the casts may be mounted quite accurately by using the entire frame. Sufficient paste is used over the edentulous area to give an accurate impression of the ridge and the approximating teeth. One small point of the record touching the edentulous area and the opposing teeth will be enough to orient the casts in relation to each other.

SUMMARY

A method of registering interoccusal jaw relations used in the crown and bridge technique at Western Reserve University, School of Dentistry has been described. This method has been an improvement over that used previously in the school.

Western Reserve University
School of Dentistry
Cleveland 6, Ohio

FLEXIBLE RUBBER MOLDS FOR ACCURATE MULTIPLE REPRODUCTION OF PLASTER CASTS

PHILIP R. JORAM, HELEN T. GROGAN, AND SAMUEL PRUZANSKY, D.D.S.*
*Bethesda, Md.***

A LARGE SERIES OF PLASTER casts obtained from alginate impressions of the face and palate of infants born with congenital defects of these structures has been accumulated at the Cleft Palate Center of the University of Illinois in the past seven years.[1,2] To preserve this collection and to extend its usefulness so that the casts may be transported without fear of damage and be exhibited and studied elsewhere, it was necessary to devise a method for the duplication of the original plaster casts.

Conventional methods employed for the duplication of dental casts were found to be inadequate in that they could not reproduce the extreme undercuts that characterized the cleft palate, and often the procedure threatened to damage the original cast. In addition, the available methods did not allow for multiple duplication from the same negative.

By adapting certain techniques employed in the field of medical art,[3] it was found that a new liquid rubber could be utilized to fabricate strong, flexible, elastic, and accurate rubber molds which could reproduce every undercut and irregular or complex shape without damage to the original cast. In addition, numerous duplicates could be made from a single rubber mold without apparent diminution of the accuracy of the mold. The liquid rubber employed is known commercially as liquid latex, fluid rubber, or rubber latex.

SUPPLIES AND MATERIALS

Liquid rubber (liquid latex, fluid rubber, rubber latex)
Artist brushes
Heavy cardboard
Cellophane tape
Petroleum jelly
Gauze bandages
Plaster of Paris
Chloroform
Talc powder
Modeling clay (oil or glycerine type)

Received for publication Feb. 15, 1957.
*Present address: Cleft Palate Center, University of Illinois, Chicago Professional Colleges, Chicago, Ill.
**United State Department of Health, Education, and Welfare, Public Health Service, National Institutes of Health, Medical Arts Section and National Institute of Dental Research, Bethesda, Md.

The liquid rubber and many of the supplies and materials are obtainable from most art supply and hobby stores. Many suppliers of the liquid rubber can supply helpful information on its use.

The liquid rubber is a creamy white solution of latex solids in a solvent containing ammonia. The ammonia acts as a vulcanizing agent, and its evaporation from the solution converts the liquid latex into a tough, flexible rubber. No heat or other agent is required, only air drying. The latex can be diluted by the addition of a 10 per cent ammonia solution, using either household or laboratory type ammonia. The ammonia should be added carefully and stirred into the latex. Before each use, the jar of latex should be shaken thoroughly to mix the contents.

PREPARING THE ORIGINAL CAST

The plaster cast is mounted on a heavy grade of cardboard. Cellophane tape, folded back upon itself to give two adhesive surfaces, may be used to fix the cast upon the cardboard base (Fig. 1). The cardboard base facilitates the handling of the cast when applying the liquid rubber.

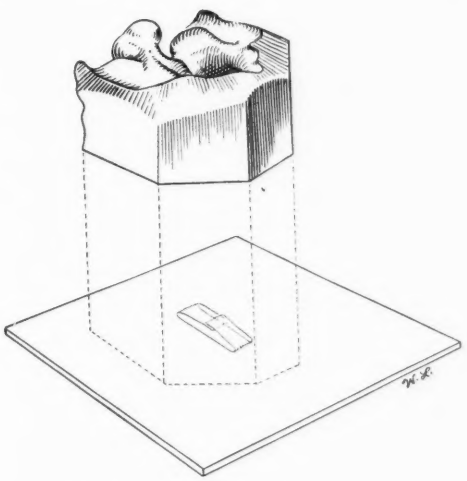


Fig. 1.—The mounting of the original cast on a cardboard base.

If the cast to be duplicated has been finished by "soaping," it may be necessary to paint it with shellac; otherwise, the liquid rubber may not adhere. One or two evenly applied coats of thin shellac will suffice. Each coat is allowed to dry thoroughly before applying the next coat on the liquid rubber. The formation of pools or runs of shellac, especially in the crevices of the cast, are to be avoided lest they produce an imperfect rubber mold.

Any "tunnels" which may connect from the inner surfaces of the cast through the sides should be sealed over with a small bit of cellophane tape. Otherwise, the liquid rubber applied to the inner surfaces will flow through, adhere to the rubber applied to the sides, and prevent the removal of the completed rubber mold from the cast.

APPLYING THE LIQUID RUBBER

The first three coats of liquid rubber applied on the cast are the most important and should be applied carefully. The rubber must be spread smoothly and evenly over all surfaces, giving particular attention to the deep crevices and undersurfaces (Fig. 2).

A clean artist's brush is employed in applying the latex. It is helpful to have several brushes for use so that when one becomes gummy another may be used. This will save time when many casts are being prepared. Dipping the brush in warm soapy water before using the latex will prevent or delay gumming.

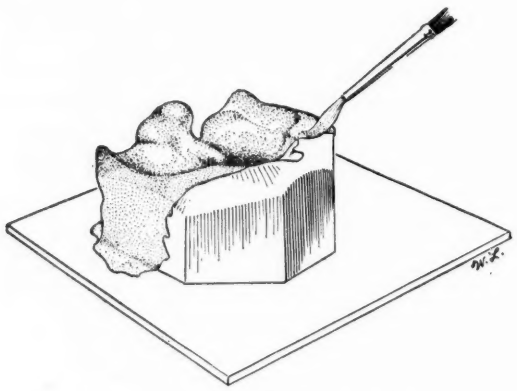


Fig. 2.—Applying the liquid rubber.

If any small areas are missed because of applying the white liquid rubber onto white plaster casts, these will become visible as the rubber dries to a pale brown color. The second and third coats should cover all surfaces. As these initial coats will pick up and duplicate all surface details from the cast, it is important that great care be exercised in their application. Usually, the first coat will dry rapidly owing to the absorption of the solvent of the latex by the dry plaster. Subsequent application of a second coat may cause the first coat to pull loose from the cast.

Four to five hours should be allowed for the drying of each coating. Ideally, two coatings a day, one in the morning and one in the afternoon, are applied until about ten layers have accumulated. Because of the deep and narrow undercuts found in the cleft palate casts, this number of coatings is necessary to prevent the rubber mold from being torn or losing its shape on removal from the cast. These additional coatings will flow on very smoothly and can be heavier than the first two layers.

After use, the brushes should be cleaned by soaking them in chloroform and pressing out the dissolved rubber with gauze rags. Continue to dip and wipe the brushes clean until all the latex is removed. Ammonia solution, the solvent of the liquid latex, has not proved satisfactory for cleaning brushes.

REINFORCING THE RUBBER MOLD

The surfaces of the mold covering deep crevices may require reinforcement. Such areas may be strengthened by applying a liberal coat of latex and then placing a strip of bandage gauze into the latex. The gauze will absorb the latex and add body to the rubber mold. One or two additional coatings over the entire cast should be sufficient to give the mold a smooth outer surface.

Care must be taken not to apply the gauze in strips or small wads in undercut areas where it would prevent the rubber from stretching or removal from the cast. One of the major advantages of the flexible mold is the ability of the rubber to narrow itself on stretching when being removed from undercuts and to spring back to its original shape.

PREPARING THE MOTHER MOLD

In order to prevent distortion of the rubber mold when pouring plaster into it, it is essential that a mother mold of plaster or dental stone be made to encompass all sides of the mold before it is removed from the original cast.

When a sufficient thickness of latex has been added to form the rubber mold, the cardboard base containing the mold is boxed in. Cardboard of the same type as that used for the base is satisfactory. If the cardboard base is 4 inches square, a strip of cardboard 16 inches long and ½ inch wider than the highest point on the cast should be cut. The strip is bent every 4 inches, and the two ends are attached with cellophane tape or masking tape. The frame thus formed can be attached to the base.

Usually the plaster shell or mother mold must be made in two parts because of the contours of the rubber mold and the undercuts still present. If, in applying the liquid rubber, the mold was built up without undercuts, a one-piece shell will suffice.

If it is necessary to prepare a two-piece mother mold, the contours of the rubber mold must be studied to determine the boundary between the two pieces. This line can be drawn on the rubber mold with a wax marking pencil and will represent those points on the rubber mold where the two pieces of the mother mold will most advantageously part from each other and slip off from the uneven contours of the rubber mold.

Modeling clay is used to build up a wall across the rubber mold from side to side and along the boundary line drawn with the wax marking pencil. The clay wall may be contoured to form a dovetail between the two finished sections. The wall (the same height as the outer walls of the cardboard frame) must be pressed firmly against the cardboard sides and the mold (Fig. 3).

Using a melted lubricant, such as petroleum jelly, paint all surfaces of the frame and mold. The clay will not need any separator. Plaster mixed to creamy consistency is poured into the lubricated section, filling it to the top of the frame.

When the plaster has set, the clay is removed and the plaster, which will be in contact with the newly poured section, is lubricated. Plaster is poured into the remaining part of the frame. Allow the plaster to set and carefully remove the four walls of the frame. It is best to delay the removal of the two-piece plaster shell from the flexible mold for 24 hours, because the surface of the shell in contact with the flexible rubber remains damp (Fig. 4).

FINISHING THE FLEXIBLE MOLD

To remove the flexible mold and the plaster cast from the cardboard base, cut under the outer edges of the rubber where it forms a lip on the cardboard. A scalpel or razor blade will do. It is necessary to cut only for a short distance, for

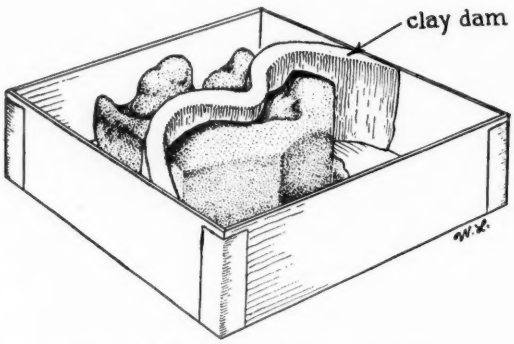


Fig. 3.—Preparing the mother mold.

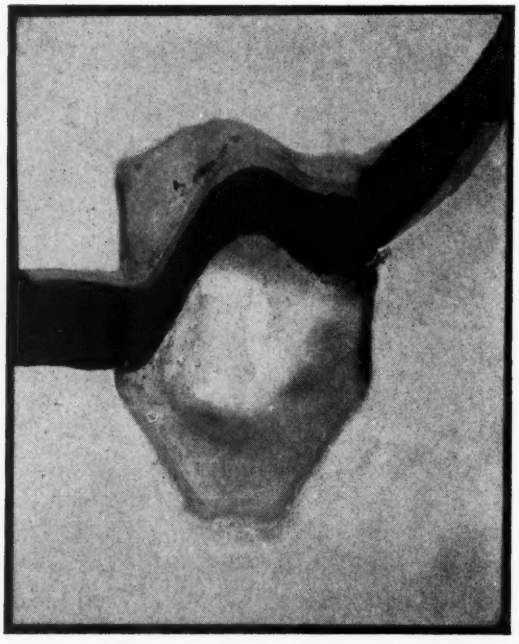


Fig. 4.—A two-piece mother mold.

once the seal has been broken the cardboard can be pulled away easily. The ragged edges of the outer lip of the rubber mold is trimmed with sharp scissors. Any rubber which covers the edges of the base of the plaster cast should be trimmed away at this time or when the cast has been removed.

Peel the flexible mold from the cast. It is well to peel all sides at the same time. It may require considerable pulling to remove the mold from some of the undercuts or deep crevices, but if the mold has been carefully built up and sufficient time has been allowed for drying, it will withstand this stretching with no difficulty.

After the rubber mold has been removed, leave it turned inside out and dust it with talc. This will prevent the inner surfaces from sticking to each other and will speed the drying. An easy way to dust the mold is to place it in a paper bag with talc and shake vigorously. Remove the rubber mold from the bag and dust off the excess talc.

The flexible mold is now ready for casting duplicates of the original. Place the flexible mold in one half part of the plaster shell and assemble the other part, dovetailing the grooves to lock the two sections together. The flexible latex mold should slip into the second part easily as it is assembled. The mold is ready for casting (Fig. 5). No separator or lubricant is needed for casting plaster into the flexible molds. The use of a wetting agent such as that employed in painting dental wax patterns prior to investment is suggested.

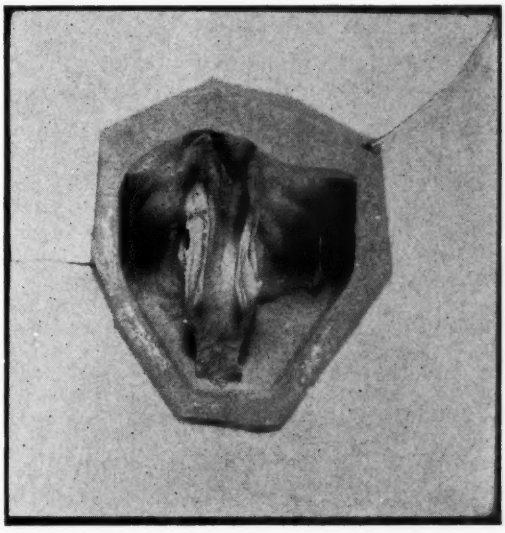


Fig. 5.—A flexible rubber mold positioned within the mother mold.

For casting with wax, the mold should be preheated in an oven and submerged in hot water immediately before pouring in melted wax. Harden the wax in a refrigerator. When the wax cast is firm, remove it from the mold.

STORAGE OF RUBBER MOLDS

Although no exact data on the changes that may occur in storage are available, our present experience, extending over a period of two years, does not indicate visible changes in the size or shape of the mold. To prevent possible shrinkage, the molds should be kept filled with plaster when not in use.

ACCURACY OF REPRODUCTIONS

By gross inspection and measurement, the duplicates, poured from rubber molds properly supported by a mother mold, were indistinguishable from the original casts (Fig. 6). To satisfy our curiosity, a more detailed and analytical comparison was made between a selected number of original casts and their reproductions.

These tests were performed by Lieutenant Commander N. W. Rupp, (D.C.) U.S.N., stationed as a guest worker at the Dental Research Section, National Bureau of Standards in Washington, D.C. A pantographic type of comparator[4] devised for measuring the mucosal surface contours of impressions, casts, and dentures was utilized in the comparison.

Comparative measurements of the contoured palatal surfaces of the original cast and its reproductions revealed a dimensional difference that rarely exceeded 0.005 of an inch.

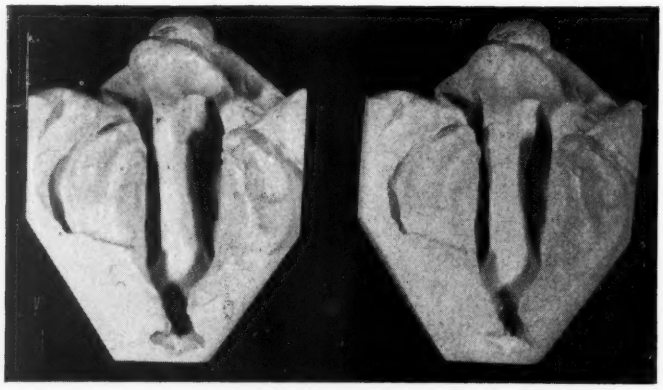


Fig. 6.—The cast on the right is a detailed and dimensionally accurate reproduction of the polished original cast on the left.

SUMMARY

A technique employing rubber latex for the multiple and accurate duplication of plaster casts has been described.

This technique provides a method for duplicating valuable casts for teaching, exhibit, and research purposes without jeopardy to the original cast.

Grateful acknowledgment is made to Mr. William Loechel for preparing the original illustrations.

REFERENCES

1. Pruzansky, S.: Description, Classification, and Analysis of Unoperated Clefts of the Lip and Palate, Am. J. Orthodont. **39**:590, 1953.
2. Pruzansky, S.: Factors Determining Arch Form in Clefts of the Lip and Palate, Am. J. Orthodont. **41**:827, 1955.
3. Travers, Ralph: Professional Molds and Castings, Boston, 1952, Plastic Service Associates, pp. 7-21.
4. Rupp, N. W., Dickson, G., Larson, M. E., Jr., and Sweeney, W. T.: A Method for Measuring the Mucosal Surface Contours of Impressions, Casts, and Dentures, National Bureau of Standards Report, 4227, June 30, 1955.

1853 W. Polk St.
Chicago 12, Ill.

CLINICAL USES OF RUBBER IMPRESSION MATERIALS AND ELECTROFORMING OF CASTS AND DIES IN PURE SILVER

W. CAMPBELL HUDSON, D.D.S.
New York, N.Y.

A DIGEST OF THE LITERATURE pertaining to the physical properties of the rubber impression materials shows agreement among the investigators as to its accuracy, dimensional stability, and ability to recover after deformation in removal from severe undercuts. The research of Skinner and Cooper,[1] Jorgensen,[2] Rosenteil,[3] Fairhurst and others,[4] and the Thiokol Chemical Corporation[5] confirms the belief of the author that the synthetic rubber base is a desirable impression material which possesses qualities equal to those of the hydrocolloids. Variables inherent to the hydrocolloids are not found in the synthetic rubber impression materials which may lay claim to some valuable properties of their own. Notable among them is the surface density and fine detail imparted to stone casts and individual dies recovered from such impressions. Casts and dies need not be processed immediately as in the case of the hydrocolloids but may be poured at a convenient time. The rubber base neither gives up nor takes water from the hydrocal material during setting. This property results in an extremely accurate cast that exhibits a harder surface than casts poured in the hydrocolloid impressions.

The ability of the Thiokol base synthetic rubber material to take a plate of pure silver to electroform casts and dies enhances it as an impression material for most prosthodontic procedures, including the making of individual crowns and inlays of either gold or porcelain. A comparison of electroformed silver with stone dies for processing inlays favors the metal type of die because of the better marginal definition, strength, ease of waxing, and finishing. The detail and accuracy of the silver dies produced by electrodeposition over rubber impressions is unsurpassed. Undercuts that have not been eliminated in the preparation are faithfully reproduced in the impression and die and, if they are not recognized and eliminated in the wax-up, they will prevent the precise seating of the crown or inlay. The circular gouging by diamond and cross-cut cylindrical instruments in the preparation of parallel walls constitutes small but precise undercuts that may prevent the proper seating of the casting. Attention to detail in the elimination of undercuts and other shortcomings in our preparations will be rewarding in the satisfaction one receives from the production of superior restorations.

The rubber base material may be used for impressions in most clinical and laboratory procedures where hydrocolloid, alginate, modeling compound, or zinc oxide and eugenol pastes have been the materials of choice. For single and multiple inlays and crowns, multiple abutments for fixed and removable partial dentures, and for complete dentures, this versatile material may be used for the production of

Read before the American Academy of Restorative Dentistry, Chicago, Ill., Feb. 2, 1957.
Received for publication March 12, 1957.

accurate casts and dies that show exquisite detail. Impressions for porcelain jacket crowns and inlays may be electroformed to produce casts and dies from which superior ceramic restorations may be made. Replacement of broken crowns on fixed bridges and unit-built porcelain jacket crown bridges may be easily and accurately made over a precise cast of pure silver which was electroformed over a rubber impression.

For complete dentures, the rubber base material is being employed for impressions and stabilized baseplates with excellent results. Trial bases with the teeth set up show better stability and retention and permit better evaluation of esthetics, phonetics, and function when they are stabilized with the rubber base material. This material is being used in electromyographic studies of muscular activity, in unstrained maxillomandibular relations, and in the study of rest position in relation to the interocclusal distance. As a result of the unstrained registrations that are made possible by the rubber base material in its thin, ungelled state, progress is being made toward solutions of the problems of jaw relationship, and the corroboration or rejection of theories pertaining to the temporomandibular joint.

DIES FOR UNIT-BUILT RESTORATIONS

Individual dies for unit-built jacket crown bridges and fixed partial dentures may be produced by a laboratory procedure which duplicates the gold framework and abutments. From a single rubber base impression made over the cast with the framework in position, the dies are made by electrodeposition, the die extensions are provided, tapered, and replaced in their original positions in the impression, and then the cast is completed in stone. The dies are removable from the cast but their relation to each other and to adjacent teeth is most accurate. Porcelain jacket crowns made over them will fit the gold framework and the abutments with precision.

The accurate marginal and internal fit of high-fusing porcelain inlays for incisal tips, mesio-occlusal bicuspid preparations, and gingival third cavities, when made over silver dies, has brought about a renaissance in the use of baked porcelain. The precise marginal fit of a porcelain inlay eliminates the objectional "ditch" with its darkened line which is seen so often in restorations made by the compound impression—amalgam die process.

The duplication of casts in stone and refractory investments by means of the rubber base materials produces accurate, finely detailed replicas with more dependable surface hardness than casts made from hydrocolloid impression materials.

New uses are being found for the rubber base material, and it is established as a dependable impression material. Recent developments have stimulated the processors of Thiokol to market the material in light, regular, and heavy bodies for different purposes.

IMPRESSION TECHNIQUES

An impression technique that makes use of the thin-bodied and the regular or the heavy-bodied material has produced excellent results where multiple full coverage abutments are used and in multiple inlay work. Bailey[6] described a special perforated tray which is made with adequate stops on the adjacent teeth and edent-

ulous areas and with 2.0 or 3.0 mm. relief over the teeth in which restorations are to be made. An alternate method involves the use of a disposable stock tray with perforations. When the preparations in the teeth have been perfected, the gingivae are retracted and the seepage is controlled by one of the effective methods. Cotton rolls are placed in position so that a dried field may be maintained during the next step. A mix of the thin-bodied material is aspirated into the barrel of a special syringe. Then, following the procedure used in the hydrocolloid technique, the mix is ejected through the angled plastic nozzle of the syringe into the floor of the cavities or into the gingival trough. Gradually, the tooth cavity or crown preparation is covered with the impression material without trapping air. The thin-bodied material has a slightly slower setting time than the regular or heavy-bodied material. A second mix of the regular or the heavy-bodied material is made to fill the special tray which is immediately positioned over the teeth which have had the thinner material injected in and around them.

In so doing, the heavy-bodied rubber exerts a compressive force on the thinner material and drives it into intimate contact with the surfaces of the teeth. When the material is thoroughly set, the tray is removed with a direct pull. The impression should show a perfect coalescence of the two materials, with the thin material spread out over a wide area. No air bubbles, voids, or moisture should be visible in the impression.

Perfect adhesion of the rubber base impression material to the painting tray is mandatory. It may be obtained by perforations and undercuts in the tray, or by one of the rubber adhesives on the inside of the tray. Sufficient time should be allowed for the material to set completely, as distortion will occur if the tray is removed too soon. The excess material on the mixing slab is an excellent guide to the progress of setting. When the excess is set, the impression in the mouth will be set because the body heat accelerates the setting. The use of the proper ratio of base to accelerator and thorough mixing (45 seconds) are important. Paper mixing pads are inadequate, particularly for mixing larger quantities of the rubber material. Polished stainless steel sheets (4 inches square) or rectangular stainless steel slabs (5 by 6 inches) serve well for this purpose. They are cleaned easily by peeling the set material from the smooth surface. Heavy mixing slabs stay put and permit the use of a large spatula with a heavy blade. The tray should be seated while the material is still in its fluid state, because strains will be set up in the material once setting has started. These strains will be released when the impression is removed and produce distortions in the impression. The tray, once positioned, is allowed to maintain itself in position. No pressure is necessary because of the viscosity of the rubber and its affinity for the oral tissues. Handled in this manner, internal strains will not be present to cause subsequent distortions.

An entirely new impression should be made if one is defective. If an impression is not acceptable, it should not be relined because relining causes distortions which result from compressive strains in the original impression material while the second mix is setting.

COMPLETE DENTURE IMPRESSIONS

Complete denture impressions made in the rubber base material have certain advantages in accuracy, in sensitivity to tissue form, and in their ease of separation

from hard dense casts. Pleasure* has suggested a simple and effective technique for making impressions for complete dentures in the rubber impression materials.

Preliminary impressions are made in alginate in a stock edentulous tray. The borders of the tray are beaded with wax to form a "rim lock." The alginate does not deform the oral mucosa because of its plasticity. However, the lingual flanges of these impressions are almost sure to be underextended at their distal ends. Casts are made in these preliminary impressions.

Individual impression trays are made by first adapting double thickness shellac baseplates over the preliminary casts and then stretching them slightly by readapting them over a layer of wet chamois on the cast. For convenience, a handle is attached to the baseplate tray with scrap baseplate material. Green stick modeling compound is used to extend and perfect the borders to the limits of the labial and buccal reflections. The maxillary tray should be extended posteriorly 3.0 or 4.0 mm. beyond the distal end of the finished denture. The lingual border of the mandibular tray is trimmed with stick modeling compound in the region from the first molar to the first molar. This border is thickened to a 7.0 to 8.0 mm. roll; it is merely seated, and the borders are not molded by tongue movement. An adequate amount of the impression material is mixed and applied generously to all contact surfaces of the tray. The excess is piled up in the palatal vault of the upper tray, and the tray is positioned in the mouth with a slight pressure which is maintained steadily for about four minutes.

The progress of the setting of the material may be tested on the labial flange. Indented by the fingernail, the mark quickly fades out if the material has set. The impression is carefully teased out of the mouth, rinsed, dried, and inspected. It may be returned to the mouth safely to test the retention and stability. The postpalatal seal is made on the master cast. The borders of the impression will be well molded and, when they are faithfully reproduced in the finished denture, the borders of the denture rarely require trimming or adjustment. No relief is necessary for hard areas or foramina because they have not been deformed during the impression procedure.

THE LOWER IMPRESSION

The lower tray is loaded in the same manner as the upper, but excess material is piled on both lingual flanges near the distal ends. As the loaded tray is inserted, the patient is asked to raise the tongue and allow it to fall lightly upon the tray which is then seated with light pressure applied in the premolar areas. Overextension of the borders is to be preferred to deformation of the mucosa covering the ridge. Overextended borders in the finished denture are reduced by judicious trimming; relief of supporting areas is rarely required.

Small defects in the impression are ignored and corrected by scraping the master cast. When large voids occur, the material is stripped out of the tray, and a new impression is made. No adhesive or perforations are used on the shellac base, so material strips away from the tray quite easily. Creases and flow lines in the impression indicate that too long a mixing time was used or that a partial set had occurred when the impression was being positioned. The mixing of the material must be rapid and complete, as indicated by the absence of white streaks.

*M. A. Pleasure, personal communication.

IMPRESSIONS FOR REMOVABLE PARTIAL DENTURES

Impressions for removable partial dentures are made in disposable perforated stock trays filled with the regular or heavy-bodied material. The filled tray is positioned in the mouth after all key surfaces of the teeth and soft tissue surfaces have been covered with the thin-bodied material ejected from the syringe.

Good results are obtained also by first making an impression in the regular material in a disposable perforated tray. The resulting impression is then covered with a mix of the thin-bodied material, reseated in the mouth, and maintained in position until the new thin material is fully set. This method is open to possible criticism because a slightly undersized cast with possible distortions from released strains may be produced. The importance of these factors is yet to be evaluated, but from a practical standpoint, many well-fitting, removable partial dentures are being made by this method.

IMPRESSIONS FOR FIXED PARTIAL DENTURES

The combination mix of light- and heavier-bodied materials may be used in a similar disposable stock tray or in a custom-made acrylic resin tray for making impressions for fixed partial dentures. The special syringe is used to inject the light-bodied material into the prepared cavities, or about the crown preparations as a preliminary to positioning a tray filled with the heavier-bodied material over the prepared teeth.

Individual impressions of abutments may be made in copper bands provided with acrylic resin or modeling compound stops. These impressions are made one or two at a time and not removed from the abutments until an impression in the same material of the entire jaw is made over the individual impressions in the bands. Upon removal from the mouth, the individual impressions will come away with the complete arch impression and maintain the correct relationship between the teeth, tissue, and abutments. Better subgingival coverage is possible when banded impressions are used, and the thin fins of interproximal tissue are eliminated. This procedure has produced excellent results.

INDIVIDUAL BANDED IMPRESSIONS

The copper band may be prepared in seconds. A band that fits loosely, but not too loosely, is selected. It is festooned, and the lingual and buccal contours are removed (in the case of an inlay) and then scored on the inside in a circular manner with an old diamond instrument for better retention of the rubber. Cuts 1.0 or 2 mm. long are made about the band on the occlusal or open end. Each section, between the cuts, is turned outward and downward onto the outside of the band to provide reinforcement for the band and attachment for a base of modeling compound or acrylic resin which is added to close this end of the band. On impressions for individual inlays and crowns, the turned-over edge provides a handy ledge against which a lever may be engaged for removal of the impression. As leverage is applied, the band is steadied on the opposite side by the thumbnail which engages the ledge on that side. This facilitates the withdrawal of the impression in an axial

direction. Distortion of the impression is caused frequently by band distortion when the impression is removed by tilting or rocking or by grasping it with a pair of forceps.

CASTS OF OPPOSING OCCLUSAL SURFACES

Counter casts which are used in extensive restorative procedures may be made from rubber impressions. The teeth of these casts may be electroformed in pure silver. The critical parts of the impression are electroplated, and the cast is completed in stone. Such a cast has advantages over stone casts. Cusp wear is eliminated, and carbon paper is not needed for refining the occlusion, as the silver cusps make a precise mark without a smear. In exacting hinge axis mountings and the precise accommodations of modern articulating devices, the preservation of cusp height on the counter cast is important in refining the occlusion.

Electroforming of individual and multiple dies and casts from rubber base impressions was first tried in copper, but undependable results lead to the use of the silver-plating process. Copper-plated dies were less accurate and were lacking in the fine detail shown by the silver. Where the metalized conducting surface is applied to the impression in the form of a metallic suspension in a lacquer vehicle (as in copper plating), it acts as a separating medium and occupies space between the impression and the resultant copper die. The variable thickness of the film not only glosses over the fine detail of the impression, but results in a slightly undersized die, since the metalized film does not become an integral part of the die. In the silver-plating process, a finely divided pure silver powder is impregnated into the surface of the impression. When the excess of powder is blown away, a bright metallic surface remains which proves to be a perfect electrical conductor for the deposition of silver. In the application of various conducting surfaces in copper plating, there is poor electrical conduction between the metallic particles themselves. All such metalizing bronze powders have been coated with a stearine for more practical handling. This insulates one particle from another and results in poor conduction and, hence, poor pulling power.

The pure silver powder is a perfect conductor even in the microscopic thickness used, and it has another very important advantage in that it becomes part of the die. Great accuracy and the reproduction of the most intimate detail are characteristic of silver-plated dies which, when separated from the impression, show the clean, bright, sharp crispness of a newly minted silver coin.

EQUIPMENT FOR ELECTROFORMING

The equipment necessary for silver plating includes the following:

1. A plater with a rectifier that will deliver a variable milliamperage of 0 to 500. The voltage varies from 1 to 4, dependent upon the current intensity used or the amount of work being plated.

2. The plating tank may be of hard rubber, glass, or various plastics. The principal requirements are that it not affect the plating solution or be affected by it. The tank should be strong and enduring and of a size in keeping with the work to be plated. The hard rubber tanks used for developing film are the most practical and easily secured. These come in various sizes, and excellent results are obtained from a small one using one quart of solution. Where a greater amount of work is

to be processed at one time, and particularly where complete arch impressions are to be plated, the larger size tanks are desirable. The cathode suspension clip mounted near the top on the inside of the tank and the anode holder are best made of stainless steel. Each of these must have electrical continuity to a binding post on the outside of the tank. A well-fitting cover for the tank prevents contamination and retards evaporation of the solution.

3. The cathode holders, on which work is to be mounted, may be lengths of insulated copper wire, stainless steel wire, or any of the holders sold commercially. For large impressions, the insulated wire is most useful and adjustable for positioning the impression in the tank.

4. An anode of pure silver, the size and weight dependent on tank size, shape, and volume. More than one anode may be advisable, particularly in long narrow tanks.

5. The plating solution is a double cyanide of potassium and silver, the formula being:

Silver cyanide	4 oz.
Potassium cyanide	7½ oz.
Potassium carbonate	6 oz.

for each gallon of solution. The salt is dissolved in distilled water. As evaporation lowers the level of the solution in the tank, distilled water is added to maintain the proper level and specific gravity. When kept free from contamination, the solution is good indefinitely.

6. Wire connectors between the plater and the tank.

7. Metalizing powder of pure silver and a lacquer suspension of the pure silver powder.

8. Sable brushes No. 000, No. 1, No. 3.

PREPARATION FOR ELECTROPLATING

The impression to be plated is first washed thoroughly with a 50 per cent mixture of hydrogen peroxide and ethyl alcohol to remove all traces of blood, mucus, or other foreign matter. When dried, a small sable brush is used to apply the dry silver powder to the surface of the impression. With a stippling action, the powder is worked into all areas to be plated. The excess powder is blown out completely and should reveal a satiny surface of uniform coverage. When spotty areas are observed, the process is repeated. Any surfaces which are not to be plated are covered with baseplate wax or a thick coat of colored model gloss before the impression is mounted on the cathode holder by means of wax. A short conducting lead is painted from the cathode rod to an area of the impression which does not involve a margin. A silver metallic lacquer suspension (Staco 101) is used for the purpose. It is allowed to dry for a few minutes, and the cathode holder with the mounted impression will be ready for the plating bath.

OPERATION OF PLATING EQUIPMENT

The anode is suspended in the solution by a stainless steel hook. The mounted impression is swished gently back and forth to completely wet the surface to be

plated. Air bubbles on the impression surface should be tapped out until it is certain that the solution covers all surfaces. The holder is clipped to the cathode rig before the current is turned on. The amperage is adjusted to read about 10 Ma. for each tooth impression being plated. Less amperage is used for an overnight plate, and more is used for an emergency quick plate. A satisfactory die may be obtained in as little as four hours, but the slower overnight plating is preferred because it produces a denser, finer grain deposition of silver than the faster plating.

Where large impressions are being plated, we allow 10 Ma. per tooth, plus 20 Ma. for leads. For example, where eight teeth are being plated, 100 Ma. are used. This is in addition to whatever else may happen to be in the tank.

The tank is kept covered at all times to prevent contamination and evaporation. When not in use, the anode is removed from the tank, washed, and laid aside. Filtering of the solution is done periodically to remove the debris, and the sheddings of the anode which are saved and used for retention of die extensions.

Contrary to the belief of many, the cyanide solution is relatively safe. It is dangerous and even lethal if acid should accidentally be spilled into the solution. Positioning the silver-plating apparatus at a distance from acids and the acid copper-plating solutions is a precaution worth taking to avoid accidents.

CONCLUSION

Various applications for the rubber base impression materials and techniques for their use have been suggested. In the use of any medium, an understanding of the material is important in obtaining the best results. With the Thiokol base, this is doubly important because any preparatory shortcoming or faulty technique will seriously affect the end result. No better stimulus toward the production of better cavity preparations is possible than observations of the deficiencies of preparations as revealed so dramatically by the synthetic rubber impression material.

The rubber impressions may be silver plated by a relatively simple procedure. The electroformed casts and dies in pure silver compliment the detailed accuracy of the impressions and make possible the production of superior restorations which are rewarding to the dentist for his efforts. A simple technique for electroplating rubber impressions was described in detail.

REFERENCES

1. Skinner, E. W., and Cooper, E. N.: Desirable Properties and Use of Rubber Impression Materials, J.A.D.A. **51**:523-536, 1955.
2. Jorgensen, K. Dreyer: Thiokol, Tandlaegebladet, p. 693, 1954.
3. Rosenteil, Edwin: Rubber Base Elastic Impression Materials (A Preliminary Note), Brit. D. J. **98**:392-394, 1955.
4. Fairhurst, C. W., Furman, T. C., Schallhorn, R. V., Kirkpatrick, E. L., and Ryge, G.: Elastic Properties of Rubber Base Impression Materials, J. Pros. Den. **6**:534-542, 1956.
5. Thiokol Liquid Polymer LP-2, Bulletin of Basic Information, Thiokol Chemical Corp., Trenton, N. J.
6. Bailey, L. Rush: Acrylic Resin Tray for Rubber Base Impression Materials, J. Pros. Den. **5**:658-662, 1955.

630 Fifth Ave.
New York 20, N. Y.

THE DISCLOSURE OF CLEAVAGE AND FRACTURE LINES IN PORCELAIN RESTORATIONS

MAURICE J. SAKLAD, D.D.S.*
New York, N. Y.

THE DESIRE FOR IMPROVED esthetics has resulted in a greater need and use for porcelain as a restorative material. However, fragility remains as its undesirable quality. The fragility shows up in three types of fracture of jacket crowns.

TYPES OF FRACTURES

The breakage of porcelain crowns may be grouped according to their location as half-moon, vertical, or multiple fractures.

The "half-moon" type of fracture is generally found in a crown where the preparation lacks adequate length. Most of the occlusal force from the opposing dentition is received by the porcelain. In other words, there is insufficient tooth structure beneath the jacket crown to provide the necessary cushioning of the masticatory force.

The "vertical" type of fracture can be generally attributed to a preparation of insufficient width, or one that has an unequal thickness of porcelain on its various surfaces. Here the fracture can be related to *rotational* stresses resulting from eccentric movements of the mandible.

The "multiple" type of fracture results in the complete shattering of the porcelain restoration. This may be caused by insufficient occlusal clearance, or by the general disregard for the physical limitations of the porcelain restoration by the patient. In most instances, this can mean a failure of the patient to adjust his eating habits.

CAUSES OF FRACTURES

The causes of fractures can be divided into three groups. One group of causes is within the control of the dentist, one is within the control of the technician, and one is within the control of the patient.

The dentist is responsible for the preparation. Any error in the preparation predisposes toward fractures. One of the most frequent causes for fracture is the unequal thickness of the porcelain crown. This must be considered when the preparation is made. Brecker[1] writes, "The most important principles in porcelain jacket crown construction are that the crown be baked to near equal thickness and

Presented before The Greater New York Academy of Prosthodontics, Dec. 2, 1956.
Received for publication March 16, 1957.
*Instructor, Department of Fixed Partial Prosthesis, New York University, College of Dentistry.

that it have sufficient tooth structure to be supported. Equal thickness of porcelain minimizes fractures and contributes to uniform better color."

The modern concept of the jacket crown restoration dictates that there cannot be any set rules for the steps in the preparation of a tooth if we expect the crown to meet the essential requirements. It is not necessary to have a shoulder for all porcelain jacket restorations. The shoulder affords a finishing line for the termination of the jacket crown or a recess to accommodate sufficient thickness of a veneer, thus insuring favorable color, a proper contour, and healthy gingivae. The shape, alignment, and position of the tooth dictate the necessity for a complete or a partial shoulder. In turn, the need for a shoulder dictates the order and amount of surface reduction from the tooth. The premature removal of the incisal edge is often responsible for the mysterious creation of a shortened preparation and the subsequent lack of retention of the finished porcelain restoration. The incisal edge is the easiest to be prepared and should be treated last.

Additional flaws in preparations are the insufficient removal of tooth structure, sharp edges or corners, excessive taper, lack of sufficient width, a cylindrical shape of the stump, and insufficient coronal support. In the case of nonvital teeth, the incorrect choice of the type of post, the length of the post, the type of coronal support, and the coping may be disturbing factors.

Other possible errors by dentists, which tend to cause fractures, are: grinding the porcelain with a thick or coarse stone, grinding too rapidly, and improper cementation procedures.

The technician may make errors which predispose toward fractures. Among these are: improper baking, unequal thickness, poor condensation or mixing of porcelain, too rapid firing with the too rapid elimination of water which leaves voids in the porcelain that can be the beginning of cleavage lines, too rapid cooling, too many firings, grinding with a coarse stone, grinding too rapidly, and attempting to compromise between an inadequate preparation and the desire to produce a pleasing esthetic result.

A flaw or an error in the porcelain restoration may pass unnoticed by the dentist or technician because the final glaze frequently masks tiny discontinuities. When a crown with these defects is seated, it will not be long before the patient returns to the dentist with the complaint, "I can't remember eating anything hard and my porcelain jacket broke."

PROCEDURE TO DETERMINE A POSSIBLE FRACTURE

The human eye has been considered sufficiently sensitive to detect any discrepancies in the porcelain. However, we must recognize that a flaw may have been overlooked by the dentist and the ceramist which becomes manifest only after cementation. If we could be certain that no defect was present prior to cementation, much difficulty could be avoided. This can be done only after examination by a standard, nondestructive, simple method of inspection after the platinum matrix has been removed.

In place of the inexact visual method, a dye penetrant is used as an inspection device for locating flaws in porcelain restorations when they are open to the

surface. The penetrant enters any crack or void and is held there by capillary attraction. It is not removed by wiping or rinsing. With this method, fractures in areas that are usually impossible to view with the naked eye can be located.

The testing materials* consist of cleaner, penetrant, and developer. In addition, three dappen dishes, three sable brushes, an applicator, and sticky wax are needed (Fig. 1).

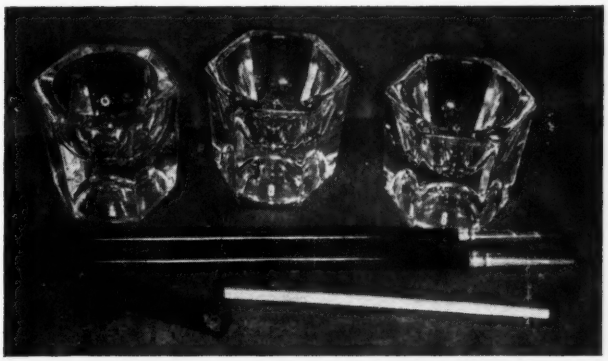


Fig. 1.—Three dappen dishes, sable brushes, wooden applicator, and sticky wax.

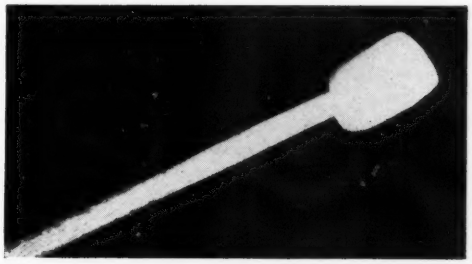


Fig. 2.—A porcelain jacket crown is luted to an applicator with sticky wax.

The porcelain jacket or other ceramic restoration to be tested is luted to the applicator by means of sticky wax (Fig. 2). A small quantity of the cleaner is placed in the first dappen dish. This is applied generously directly to the restoration with the sable brush. Time is allowed for the solvent to act on the surface; then the restoration is wiped clean with a dry rag or tissue. This cleaning can be repeated, but it is important that the porcelain be allowed to dry completely.

A small amount of the penetrant is placed in the second dappen dish. This penetrant is a red dye. It is applied to the dry surface with a sable brush (Fig. 3). It is best accomplished at 60° F. or above. The entire porcelain surface is generously covered with the penetrant, and it should remain wet from one to thirty minutes before the excess is wiped off. If the penetrant dries before wiping, the surface should be rewet.

*Spotcheck, Number 1 (cleaner), 2 (penetrant), 3 (developer); Magnaflux Corporation, Chicago, Ill.

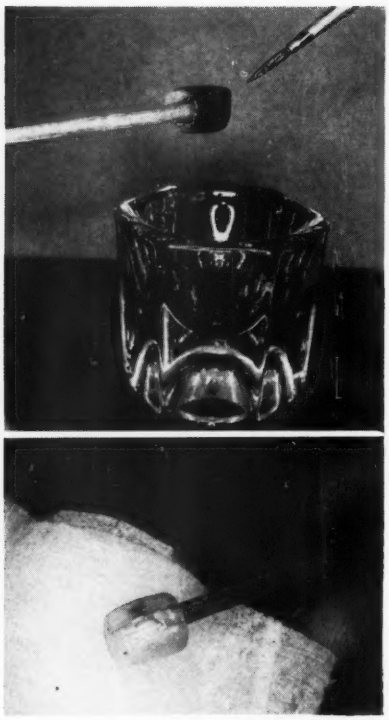


Fig. 3.

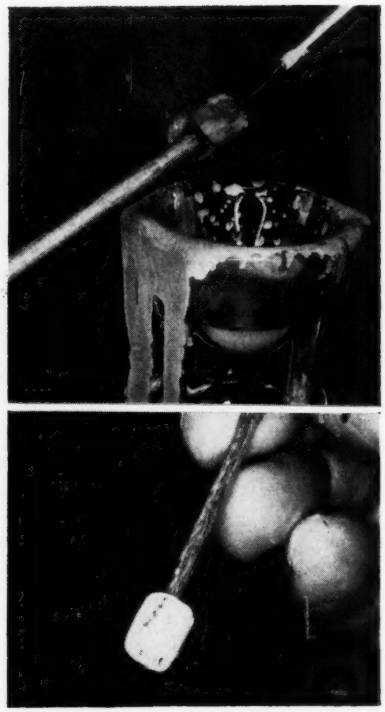


Fig. 4.

Fig. 3.—*A*, the penetrant, Spotcheck No. 2, is applied to the porcelain jacket crown. *B*, The surface of the porcelain jacket crown is wiped with clean gauze.

Fig. 4.—*A*, The developer, Spotcheck No. 3, is applied to the porcelain jacket crown. *B*, The developer is allowed to dry.

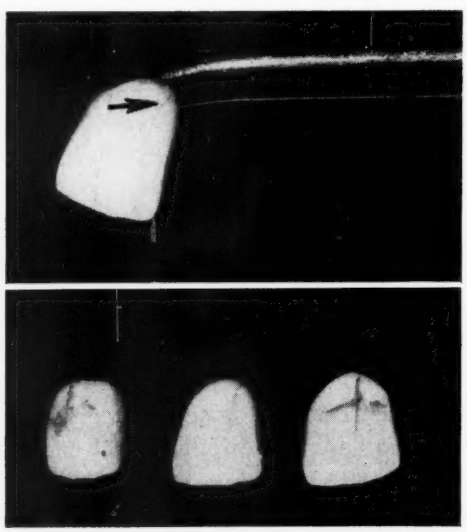


Fig. 5.—Evidence of fracture lines revealed by the test.

The porcelain surface can be wiped best with successive clean areas of a cloth or with paper tissues (Fig. 3). If difficulty is encountered, the cleaner can be reapplied before wiping.

The developer is applied next. The contents of the can are thoroughly shaken, and a small amount is placed in the third dappen dish. This is applied to the complete outer surface of the restoration with a sable brush (Fig. 4). It forms a white frosty finish. The material should be generously applied to wet the surface completely. A five-minute drying period will permit the disclosure of fractures. These will appear as red lines or blemishes in the porcelain.

The restoration is dried with a clean cloth or paper tissues, and any fracture will be evident (Fig. 5). The absence of any red markings indicates a fracture-free restoration. Any porcelain restoration which passes this test is free from defects and can be cemented in position.

This procedure removes any doubt as to the existence of any undetected fractures prior to cementation. This same test can be successfully applied to all porcelain restorations.

REFERENCE

1. Brecker, S. C.: The Porcelain Jacket Crown, St. Louis, 1951, The C. V. Mosby Co., p. 15.

45 West 54th St.
New York 19, N. Y.

PORCELAIN VENEERS BONDED TO GOLD CASTINGS—A PROGRESS REPORT

JOHN F. JOHNSTON, D.D.S.,* R.W. DYKEMA, D.D.S.,** AND D. M. CUNNINGHAM, D.D.S.***
Indiana University School of Dentistry, Indianapolis, Ind.

PORCELAIN VENEERS FUSED TO gold castings have been used clinically long enough to permit a critical evaluation of the materials and the methods of fabrication. This article will be limited to the one combination of materials which may be worked by using equipment normally found in the dental office laboratory.

The casting alloy has a fusing range from 1880 to 1930° F., the solder flows at 1800 to 1830° F., and the porcelain matures at 1650° F. Both in the clinic and in the testing laboratory the bonding of the veneer seems to be more than adequate, breakage is almost nil, and the form, color, and surface texture produced are stable in the oral cavity. The gold alloy has exhibited highly satisfactory properties. The soldering continues to be an exacting procedure.[1]

The production of shades and textures in harmony with the teeth remaining in the mouth poses the problems.

At a workshop† attended by four ceramic technicians and four dentists, each of whom has had much experience with these materials, the difficulties encountered by each individual were discussed and compared. Then courses to pursue by which these obstacles might be overcome were suggested and attempted.

COLOR PROBLEMS

A considerable number of shade specimens were fused and a four-unit upper posterior bridge, a three-unit upper anterior bridge, three lower cuspid crowns, and an upper lateral incisor crown were constructed for patients. There were initial successes and failures. Satisfactory shading was eventually realized in all but one case, but when it became necessary to reconstruct the veneers in two cases, the shades could not be duplicated.

Read before the American Academy of Crown and Bridge Prosthodontics, Chicago, Ill., Feb. 3, 1957.
Received for publication April 19, 1957.
*Professor and Chairman, Crown and Bridge Department.
**Associate Professor, Crown and Bridge Department.
***Assistant Professor, Crown and Bridge Department.
†Workshop on Porcelain Veneers Fused to Gold Castings. Sponsored by Indiana University School of Dentistry and held at Indianapolis, Indiana, Jan. 27 to Feb. 1, 1957.
Participants: Mr. Harry Dunton, The Enquirer Building, Cincinnati, Ohio; Mr. Roy Wain, The J. M. Ney Company, Hartford, Conn.; Mr. Bernard Scullin, The J. M. Ney Company, Hartford, Conn.; Mr. Daniel Sullivan, The J. M. Ney Company, Hartford, Conn.; Dr. Roland W. Dykema, Indiana University School of Dentistry; Dr. Donald M. Cunningham, Indiana University School of Dentistry; Dr. Hector Davila, Indiana University School of Dentistry; and Dr. John F. Johnston, Indiana University School of Dentistry.

The failure in shade was in the crown for the upper lateral incisor. No shade guide could be found which approached the color to be matched. It is believed now that the correct basic colors have been selected for this crown, but combining them in the proper proportions is yet to be achieved. If the approximating teeth in *this* mouth can be matched, anything is possible!

Initially, colored opaques were used in constructing these porcelain veneers, but when the materials and process were presented to the profession, only a white opaque was manufactured. It was felt that the porcelain powders or S.S.W. 1600° F. stains could be used whenever a stained opaque was essential. A number of people have recommended that colored opaques be made available by the manufacturer.

It was shown conclusively that the 1600° F. stains burned out during the repeated firings necessary, and that the porcelain powders did not alter the white opaque sufficiently.

Other conclusions were:

1. The opaque must be available in at least three colors, namely yellow, orange, brown, and the white. (There is some sentiment in favor of a blue opaque, also.)
2. The opaque must have a greater fusing range than at present.
3. Testing must be done to determine the effect of vacuum firing on the opaque.

Dr. Richard Hunter,* inventor of the Hunter Color and Color-Difference Meter, feels that the opaque should be darker than the shade desired in the finished veneer.

A translucent porcelain, to be combined with the basic porcelain powders, has been developed experimentally. With this new powder, veneers which are much more lifelike have been produced in quantity in the laboratory. This porcelain was used for the first time in the construction of clinical cases during the workshop. If the translucent porcelain is added in the right proportions (that is, with some restraint), it should aid materially in the fabrication of veneers which have "life" and "brilliance."

Of course, translucency is not always desirable. While highly translucent teeth may be acceptable in the construction of complete dentures, they cannot be used harmoniously in the partially edentulous arch in all patients. However, this translucent porcelain powder has been needed to facilitate the construction of a majority of the veneers.

The addition of the translucent porcelain powder will necessitate a complete overhauling of the formulae for reproducing the colors in the various shade guides. Then, when the new powder combinations over colored opaques are available, still another set of shading problems arises.

It is to be hoped that the manufacturer will introduce a shade guide for the porcelain and not try to create powder combinations which, when fused, will be expected to match existing shade guides. If it is impractical for the manufacturer to do this, it is advisable for the dentist to make up a shade guide for his own use. If this were done much time could be saved.

*Dr. Richard Hunter: Unpublished Consultants' Report.

It appears imperative that the available basic shades be studied carefully, especially the yellow series. When this has been accomplished, a further re-evaluation of the shade formulae may be in order.

METHOD OF FIRING

Certain questions regarding the firing of this porcelain remain unanswered: Should the opaque porcelain be fired in a vacuum and, if so, will the bonding be complete? If the opaque porcelain is air-fired, then subjected to the vacuum when the veneer is fused, will air voids appear, and will the bond be reduced? How many times can the veneer be subjected to vacuum firing without the formation of gas bubbles? What method of firing produces the best surface texture, both with and without the use of an overglaze? We feel that we know the answer to some of these questions, but as yet we have insufficient clinical data to make positive statements regarding them. However, by building two veneers from the same mix of powders similarly condensed, and firing one in an air furnace and the other in a vacuum furnace, it was demonstrated that the resulting shades were quite dissimilar. Those fired in the vacuum furnace were darker, and they were more "natural" in appearance.

Much progress has been made during the past year, and the answers should be forthcoming in much less time than was needed to perfect plastic veneers to their present quality.

REFERENCE

1. Johnston, John F., Dykema, R. W., and Cunningham, D. M.: The Use and Construction of Gold Crowns With a Fused Porcelain Veneer—A Progress Report, J. Pros. Den. **6**:811-821, 1956.

1121 West Michigan St.
Indianapolis 2, Ind.

THE USE OF RUBBER BASE IMPRESSION MATERIALS IN THE CONSTRUCTION OF INLAYS

MORTIMER C. DAVIS, D.D.S.
Jersey City, N. J.

THE PROBLEM OF REPRODUCING the cavity preparation, tooth contour, and contacts for single and multiple inlay work has always been a difficult one to solve. Prior to the introduction of the hydrocolloid impression materials, three methods were commonly used, all of which had certain disadvantages. These three were generally classified as: (1) indirect, (2) indirect-direct, or (3) direct.

THE INDIRECT METHOD

In the indirect method an impression of the prepared tooth or teeth was taken, and a die was made, either by copper-plating the impression, or by using amalgam or stone. The die was seated and secured in an interocclusal registration (made with varying degrees of inaccuracy), after which the cast and countercast were poured, the waxing was done, and the casting was made.

The material most commonly used in this method is impression compound. While it has always been one of the most widely used dental materials, it has serious deficiencies as an impression material for inlay work. It is brittle and will not spring past an undercut. This alone precludes its use, even if it were sufficiently accurate, which it is not. The entire method, including die seating, cast pouring, contact area restoration, and occlusal surface development places it in the realm of guesswork.

THE INDIRECT-DIRECT METHOD

The indirect-direct method is designed to correct some of the deficiencies of the indirect method by transferring the completed pattern to the tooth for the correction of the margins, the occlusion, and the contact areas of the pattern. The difficulty is that too often, in more complex patterns, access is poor, and these corrections cannot be accomplished with any degree of accuracy.

THE DIRECT METHOD

The direct method is the most satisfactory of the three in that it uses the tooth itself as a die and thus removes the greatest cause for inaccuracy of fit.* However, it too has serious deficiencies. It is a difficult technique to master and

Presented as a projected clinic before the American Dental Association annual meeting, Oct. 4, 1956.
Received for publication Sept. 26, 1956.

requires an unusual degree of manual dexterity, with the accompanying consumption of time and production of fatigue. Strains are introduced in heating the wax, the patterns are distorted by handling, and the access is sometimes difficult.

THE HYDROCOLLOID METHOD

The need for a material which would accurately reproduce the prepared tooth along with its neighbors and a technique which would permit the easy, quick solution to the inlay problem has long been sought. The hydrocolloid method has been the finest method developed. It opened the way to the fulfillment of all of these requirements with comparative ease. However, it too has serious deficiencies. This explains why many men who are most anxious to improve their chair procedures have not included it as a regular part of their routine. The equipment is expensive and space-consuming. The preparation and supervision of the material is a constant chore. The material is weak in its structure, temperamental, and must be handled carefully.[3] Casts must be poured at once, and the hydrocolloid must be kept moist while the compound rims, which retain the pins used to secure the dowels, must be kept dry.[6] If a mispour occurs, a new impression must be made because the hydrocolloid is fragile.

ADVANTAGES OF THE RUBBER BASE IMPRESSION MATERIALS

The rubber base impression materials eliminate all the undesirable features of hydrocolloid and none of the desirable ones. They require very little special equipment, and there is no large initial cost to install the method. They are highly accurate.[1, 3] They are very elastic (essentially the same as hydrocolloid). They have an indefinite shelf life before use[3] and can be poured at almost any reasonable period of time after the impressions are made.[2, 4, 5] The surface hardness of the stone dies is not greatly reduced when the stone is allowed to set in contact with the rubber impression materials.[3] They are tough and can be separated, in most instances, without tearing. The mixing procedure is simple.

The rubber base impression material is a universal material which, if the proper techniques could be worked out, could be applied not only to inlay work, but to fixed prosthesis, removable prosthesis with clasps or precision attachments, complete denture work, orthodontics, pedodontics,[1] and any procedure where accurate reproduction of the hard and soft structures of the mouth is needed.

THE GOLD INLAY

The gold inlay is an ideal restoration for many types of cavities. It is strong, reproduces anatomy, reproduces contact and occlusion to an optimum degree, and seals the cavity from further decay. The entire inlay method is applicable in all dental offices. It is the restoration of choice for replacing the missing parts of teeth with simple cavities and those which are more extensively broken down. Of course, it is misused in cases of extensive tooth breakdown and in highly caries-susceptible mouths. In these cases, full coverage is a more conservative procedure. But for routine operative procedures, the gold inlay provides a superior dental service, *if* it fits accurately. A poorly fitted inlay is truly "an island of gold in a sea of cement."

The successful inlay method begins with good preparation and ends with a careful cementation technique. The result can be no better than the weakest link in the chain, whether that link be heating the wax, investing it, or preparing the tooth.

THE CAVITY PREPARATION

The requirements of a good inlay preparation are basic and well understood. (1) All cavity walls must be parallel or slightly diverging. (2) Line and point angles should be well defined. (3) Retention should be inherent in the outline of the cavity. (4) No undercuts should be present within the preparation. (5) All weak tooth structure should be protected. (6) Proximal surfaces should be finished with a slice or a bevel. (7) All margins should be feather-edged.

RUBBER BASE IMPRESSIONS

The successful use of the rubber base impression materials for inlay impressions depends upon: (1) the retraction or removal of all interfering gingival tissue, (2) the use of a properly constructed tray, (3) absolute dryness of all teeth included in the impression, (4) the insertion of the material into the cavity without trapping air bubbles, (5) the thorough mixing of the ingredients of the impression material, and (6) the thorough setting of the impression material before the removal of the impression.

MANAGEMENT OF INTERFERING SOFT TISSUE

When the proximal portion of the preparation extends subgingivally and must be extended further, the interfering soft tissues present a real problem. Unfortunately, not all cavities are of the same depth pulpally and gingivally, and the necessity of removing or retracting tissue occurs in at least 50 per cent of the cases. Retraction can be accomplished by two methods, mechanically or by electrosurgery. When the gingival tissues are in excellent health and only slight gingival crevice of normal depth and width exists, and when the gingival terminus of the preparation extends only slightly below the free margin, the careful insertion of No. 30 cotton thread between the tooth and the inner rim of the gingiva will accomplish enough retraction to permit the registration of the margin in the impression. There are many who advocate impregnating the thread with various hemostatic agents before inserting it. However, I have found that, in many instances, this seems to cause some subgingival hemorrhage. The mechanical action of the pressure of the thread serves to retract the tissues adequately.

When the tissues are slightly inflamed or hyperplastic, if bleeding has occurred because of laceration by rotary instruments, or if the preparation extends too far subgingivally to be exposed by retraction with thread, electrosurgery becomes necessary (Figs. 1 and 2). Using a thin blunt electrode with the dial set at about zero on coagulating current, the tissue is gently contacted with the tip or side of the electrode. As the tissue is coagulated, it is wiped with gauze or cotton to remove its surface layer. This procedure is repeated until the complete cavity outline is exposed. It is sometimes necessary to switch to the scalpel setting on the machine to remove the buccal and lingual papillae with a fine wire electrode. If the

tissues have not been previously inflamed to any marked degree, there should be little or no bleeding after the use of the electrode. Slight seepage can be further controlled by the application of hemostatic agents and pressure.

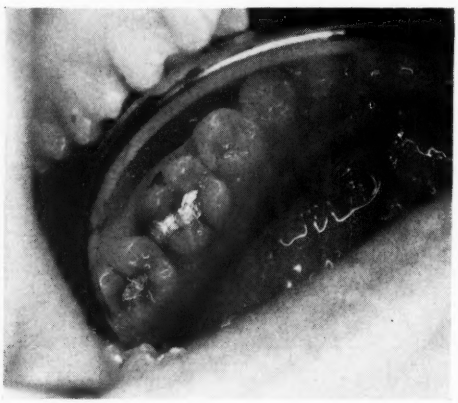
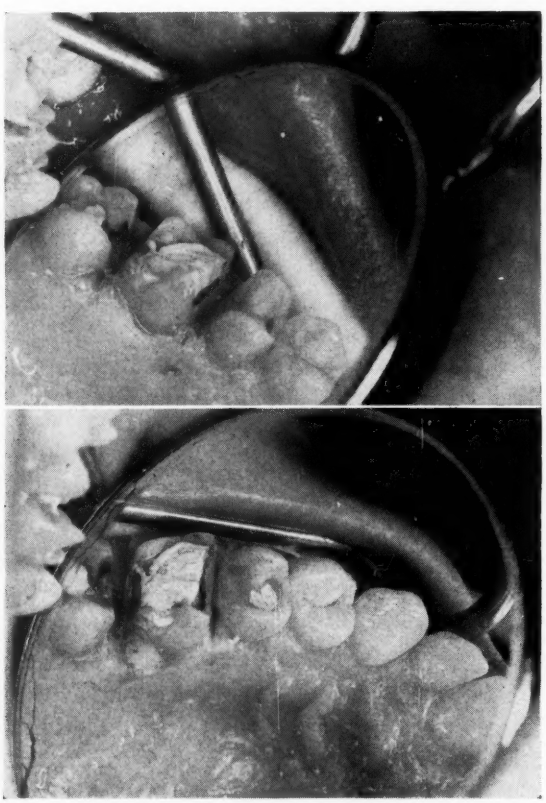


Fig. 1.—The unprepared teeth. The first and second molars and second bicuspid are to be restored with inlays.

A.



B.

Fig. 2.—A similar restorative problem showing the interproximal tissues before *(A)* and after *(B)* use of electrosurgery. Note the clearly exposed margins of the preparations.

The main disadvantage of the use of electrosurgery is that it has a tendency to cause postoperative pain, especially if care is not exercised to apply the electrode *intermittently.*

The tissues should be covered with a surgical dressing containing an anodyne paste, such as benzocaine ointment, at the conclusion of the visit. The paste can be mixed with cotton fibers, and the cavities and the tissues can be sealed at the same time. The cotton fibers permit the easy removal of the material at the next visit.

THE TRAY

At some point in procedure (while waiting for anesthesia to take effect, cement to set, etc.) the tray material is prepared. A sufficient amount of cold-cure acrylic resin polymer is placed in a jar and enough monomer is added to wet it thoroughly. Enough material should be used to form a tray for all prepared teeth, plus one or two teeth anterior and posterior to them to act as stops. There is no need to spatulate the mix. It is permitted to stand in the jar until it loses its tackiness. Then it is preformed with the fingers, introduced into the mouth, and gently molded to the teeth and slightly beyond them. It is removed from the mouth and examined while it is still soft. All excess is removed with scissors and the tray is replaced in the mouth. Upon removal (while still semisoft), it is placed in fairly hot water for 10 or 15 seconds and then reinserted in the mouth, after which it is redipped in hot water. The purpose of this procedure is to remove gross distortions from the tray. As it begins to set to the point where there is no more distortion in removing it from the mouth, it is placed in the hot water, and, in less than five minutes, it is ready for use.

Large acrylic resin trimmers are used to remove material in the imprints of the prepared teeth in order to create enough space for a thickness of at least 3 mm. of impression material.[5] The tray is painted with a rubber adhesive and allowed to dry for a few minutes. The construction of the tray does not consume more than five minutes of time exclusive of waiting time for the mix to set. This is an easy method of making a custom-built tray. This method eliminates the need for constructing a tray from a study cast.[5] It is not necessary to drill holes through the tray to retain the material, as the rubber adhesive does the job effectively.

MAKING THE IMPRESSION

After the tray is ready and the tissue is retracted or removed, the area is isolated with cotton rolls, and dried thoroughly with warm air and cotton swabs. There must be no moisture or bleeding, or it is useless to continue.

Bailey[5] advocates the use of a fine instrument to carry and adapt the mix into the cavity preparation, but it was found that no matter how much caution was exercised, it was difficult to prevent the trapping of air bubbles under the mix. Therefore, the use of a suitable syringe for introducing the mix into the preparation is essential for success.

The syringes available on the market, although they work well, are difficult to clean after use. The rubber sets, clings to the barrel, and clogs the threads

of the various metal parts. We therefore designed a simple syringe with a disposable cartridge and attached cannula. The latter is removed from the syringe and thrown away after use.

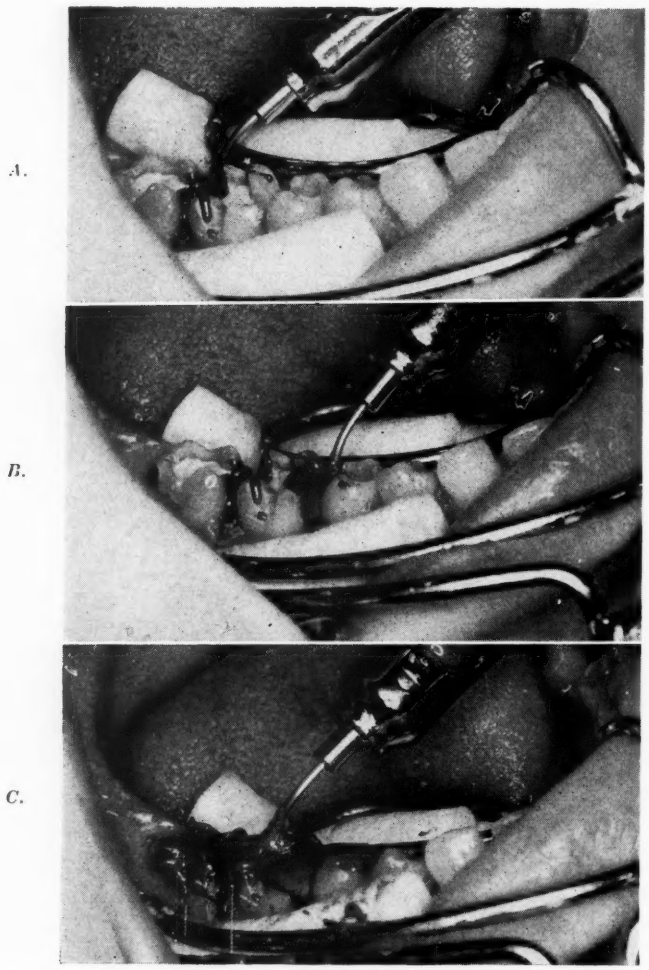


Fig. 3.—Injecting the teeth with the rubber base impression material. The deep interproximal recesses are filled first, and a continuous flow is maintained. The previously prepared tray is filled with impression material and seated over the teeth.

The rubber impression material is mixed and introduced into the carpule, which is then inserted into the syringe (very much like a local anesthetic carpule), and the material is injected into the cavity (Fig. 3). Working from the gingival margins toward the occlusal surface, the preparations are filled with the mix. Then the remainder of the material on the mixing pad is placed in the tray. The tray is seated in the mouth and held firmly in place. It is wise to be thoroughly familiar with the setting time of the material and to use a sand clock to allow for the proper setting of the material before the impression is removed.

The impression is removed with a smooth movement in the direction of the parallel walls and examined for defects (Fig. 4). If none are present, it may be placed on the bench, and the cast may be poured at any convenient time.

A wax interocclusal registration is then made with a hard baseplate wax (Fig. 5). The wax should be well softened, and the patient should be instructed to "bite hard" through the wax into centric occlusion.

Fig. 4.

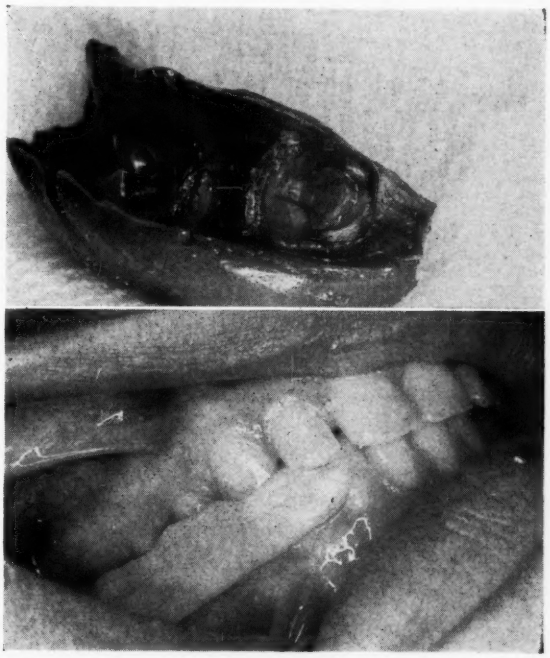


Fig. 5.

Fig. 4.—The completed impression. Note the sharp detail.
Fig. 5.—The interocclusal registration.

DOWEL ASSEMBLY

A series of straight pins are bent at right angles, and a small amount of sticky wax is placed at the rim of the impression. Each pin is fixed to the wax slightly to one side of the middle of the impression, and a small blob of wax is placed on it over the center of the preparation. The dowel is attached to the wax blob, and another pin is placed on the other side of the dowel and secured to it and to the rim. The serrated end of the dowel protrudes about midway into the impression (Fig. 6).

If there is more than one preparation to be poured into the impression, the remaining dowels are lined up approximately parallel to the first, and fixed in position in a similar manner (Fig. 6).

POURING THE DIES

Small amounts of stone are vibrated from the dowel into the deep recesses of the impression. If the stone is permitted to flow from the end of the dowel into the impression, air bubbles will not be trapped in the impression. The serrated ends of the dowels should be completely covered by the stone (Fig. 7).

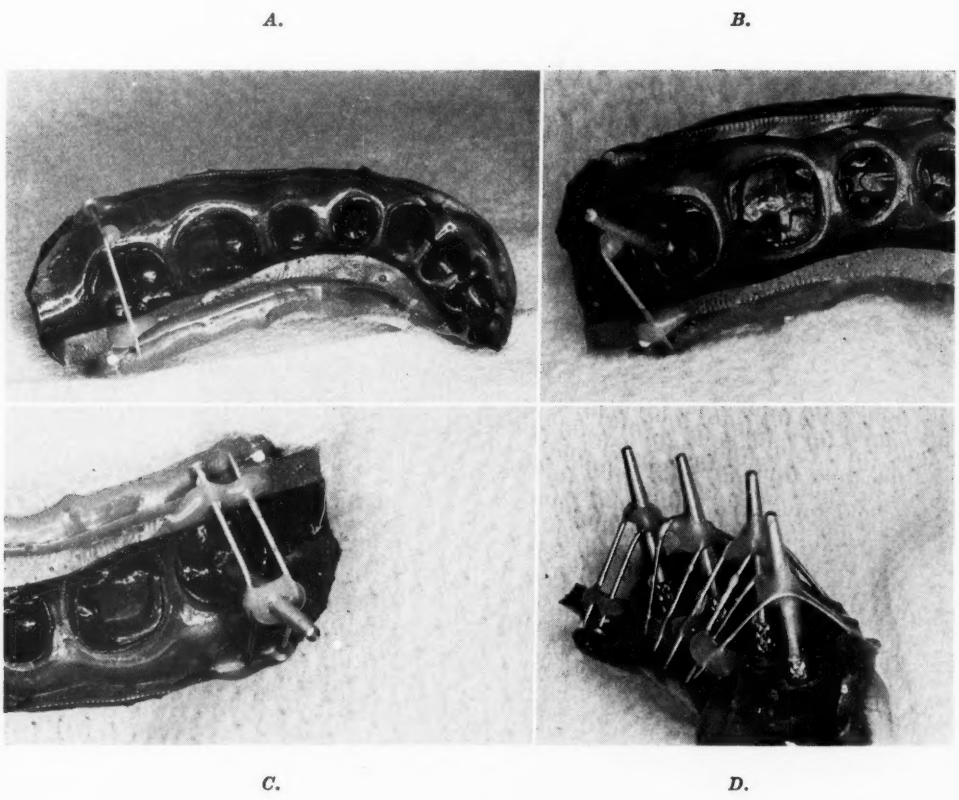


Fig. 6.—The dowel assembly. *A*, The first straight pin is bent at right angles and secured to the rim of the impression with sticky wax. A small blob of wax is placed at the center of the pin. *B*, The dowel is attached to the wax. *C*, The first dowel is assembled. *D*, The completed dowel assembly. The dowels should be centered over the preparations and should be approximately parallel and of the same height. The serrated end should project about halfway into the tooth impression.

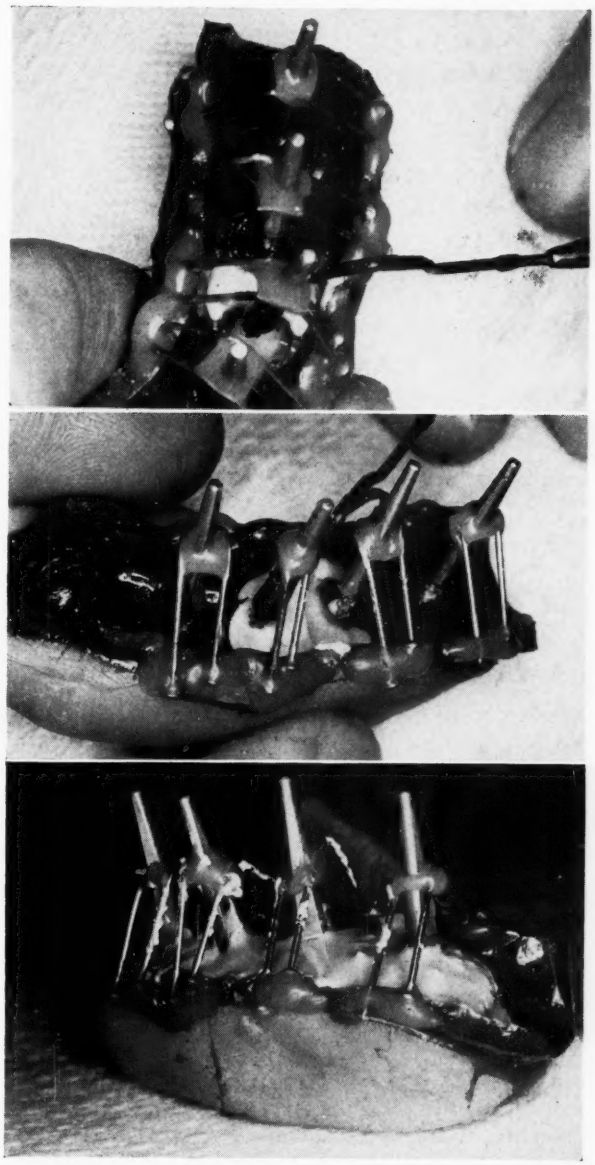
POURING THE CASTS

After the stone of the dies has set, the pins and their supporting wax are removed from the assembly. A thin coat of petroleum jelly is applied to both the pins and stone (Fig. 8), and the base of the cast is poured with stone of a different color. The interocclusal registration is positioned on the resultant cast, and the opposing cast is poured (Fig. 9).

DIE SEPARATION AND TRIMMING

A jeweler's saw is used to open a narrow cut interproximally between the dies and the unprepared teeth. The different colors of stone in the two pours are used as a guide to the depth of the cuts. The tip of the dowel is exposed in the base of the cast. Pressure on the tip of the dowel will release the die (Fig. 10).

Stones, disks, or a sharp blade may be used to define clearly the marginal areas of the dies (Fig. 11).



A.

B.

C.

Fig. 7.—Pouring the dies. *A*, A small amount of stone is vibrated from the dowel into the recesses of the impression. *B*, Additional stone continues to flow into the impression. *C*, The pouring is completed. The serrated ends of the dowels are completely covered with stone.

Fig. 8.

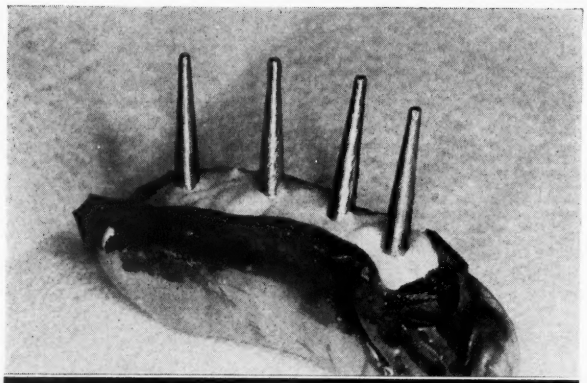


Fig. 9.

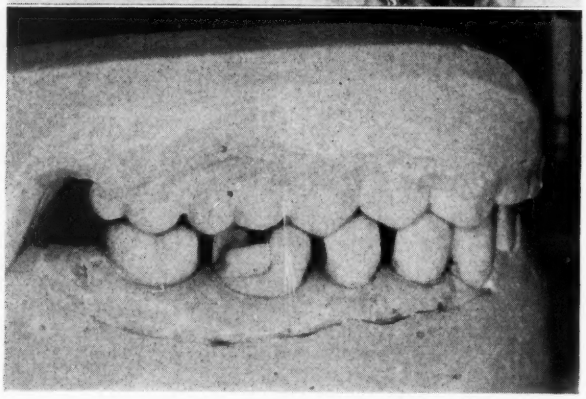


Fig. 8.—The straight pins and wax are removed, and a thin coat of petroleum jelly is painted over the stone and the dowels.

Fig. 9.—The base of the cast is poured in a different colored stone, and the cast of the opposing teeth is poured, using the wax interocclusal record for relating the two casts.

Fig. 10.

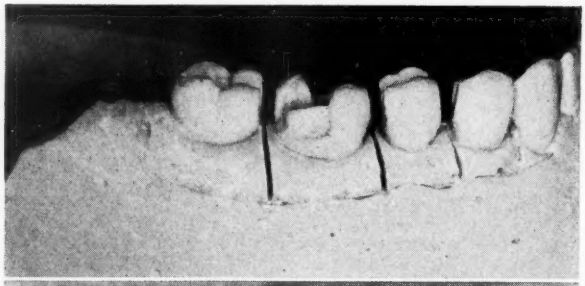


Fig. 11.

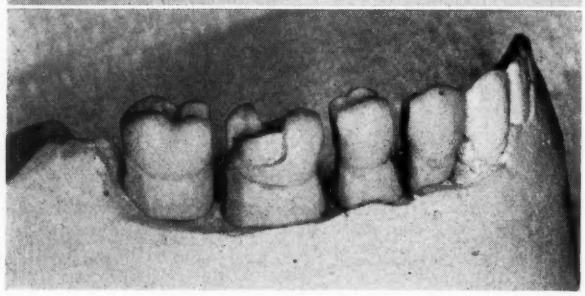


Fig. 10.—Interproximal saw cuts are made through the first pour with a jeweler's saw. The tips of the dowels are exposed in the base of the cast and pushed to release each die.

Fig. 11.—The dies are trimmed with stones and disks and soaked in oil for at least eight hours. They are then ready for waxing.

WAXING AND CASTING

Since careless waxing and casting methods can ruin the accuracy of fit of the restoration, the construction of the pattern and its reproduction in gold merit careful study. Each die is soaked at least 12 hours in oil and not removed until just prior to waxing. The oil is then blown off and a "debubblizing" agent is applied. This is thoroughly blown off and hot wax is run into the die. The wax must be fairly hot and runny so that it creeps into every portion of the die. Carving for anatomy, occlusion, and contact is completed with the aid of the cast of the opposing teeth.

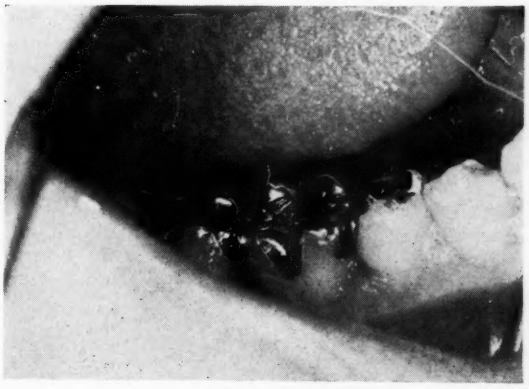


Fig. 12.—The completed casting. No contact area adjustment is necessary.

INVESTMENT

Recent investigation in casting methods[9] has shown that hygroscopic techniques have some merit as far as pattern reproducibility is concerned. Clinical evaluation of fit of castings by several casting techniques also showed the hygroscopic procedure to be more reproducible.

Asgars, and others,[9] states, "The amount of hygroscopic expansion of a dental casting investment is directly related to the specific amount of water which the investment absorbs or, synonymously, to that amount of water which may be supplied or added to the investment subsequent to mixing." Thus, by providing a controlled addition of water to the investment, a convenient and accurate means of changing the expansion is provided.

SUMMARY

A technique employing a rubber base impression material for the construction of single and multiple inlays has been described. The solutions to problems, such as tissue retraction, tray construction, impression procedure, and waxing and casting procedures have been suggested. If all steps are carefully performed, the result will be restorations of unsurpassed fit and function.

REFERENCES

1. Burket, Joseph F.: Application of Synthetic Rubber Impression Material to Pedodontic Procedures, J. New Jersey D. Soc. **26**:7-9, 1955.
2. Commonwealth Bureau of Standards: Rubber Base Impression Materials, Austral. J. Den. **59**:188-191, 1955.
3. Skinner, E. W., and Cooper, E. N.: Desirable Properties and Use of Rubber Impression Materials, J.A.D.A. **51**:523-536, 1955.
4. Rosentiel, E.: Rubber Base Elastic Impression Materials, Brit. D. J. **98**:392-394, 1955.
5. Bailey, L. Rush: Acrylic Resin Tray for Rubber Base Impression Materials, J. Pros. Den. **5**:658-662, 1955.
6. Kahn, A. E.: The Use of Reversible Hydrocolloid in the Construction of the Porcelain Jacket Crown, J. Pros. Den. **5**:687-697, 1955.
7. Davis, M. C.: Standardized Crown and Bridge Procedure, J. Pros. Den. **3**:108-120, 1953.
8. Brecker, S. C.: Electronic Surgery in Restorative Dentistry, New York J. Den. **25**:295-299, 1955.
9. Asgars, K., Mahler, D. B., and Peyton, F. A.: Hygroscopic Technique for Inlay Casting Using Controlled Water Additions, J. Pros. Den. **5**:711-724, 1955.

115 Bentley Ave.
Jersey City, N. J.

ULTRASONICS IN DENTISTRY

WILLIAM LEFKOWITZ, D.D.S.*
The Ohio State University, College of Dentistry, Columbus, Ohio

APPROXIMATELY ONE HUNDRED YEARS ago, it was learned that certain crystal elements contracted in a magnetic field. Shortly thereafter a similar property was discovered in certain metals which, if rod-shaped, contracted in the direction of their long axes. This invaluable information lay dormant until the beginning of the twentieth century when high frequency application of the magnetic field provided energy in the form of vibrations. Ultimately, vibrations were produced above the hearing range of humans to the ultrasonic frequencies. The addition of a water-borne abrasive to the vibrating device made it possible to remove hard substances. Transistors, quartz crystals, and jewels are cut in industry by this means.

It is of particular interest to note that the first industrial use of the magnetostrictive cutting device was to prepare cavities in synthetic sapphires for the reception of gold inserts. It is no wonder then that the possibility of the use of ultrasonic energy presented itself to dentistry. The first use of this cutting method was reported in the Annals of Dentistry by Dr. Matthew C. Catuna in 1953.[1] He prepared cavities in extracted teeth and reported the potential use of the ultrasonic device for this purpose. One year later, Dr. Carl Oman and Dr. Edmund Applebaum[2] reported in the *New York State Dental Journal* that an ultrasonic device had been successfully employed to prepare cavities in teeth of patients. Their report suggested several advantages of the ultrasonic method.

Since its inception, dentistry has adapted industrial uses of energy to its need. The electric engine and modern rotary instruments are prime examples. The ultrasonic device provides another form of energy for dentistry.

Dentistry, ever alert to improve its service, accepted the challenge and responsibility to determine the safety, effectiveness, and extent of usefulness of ultrasonics. Investigators throughout the nation in dental schools, hospitals, and the Armed Services undertook one of the most extensive and comprehensive research programs in the history of dentistry.

There is a logical procedure for such a program. First, the safety of the instrument must be established. Secondly, techniques of use should be developed and taught to the members of the profession. Since energy is used in many aspects of dental service, the widest desirable application of ultrasonics should be explored.

Introduction to the Symposium on Ultrasonic Dentistry, Miami Beach, Fla., Nov. 3, 1957.
Received for publication Oct. 25, 1957.
*Chairman, Division of Operative Dentistry.

In the short span of three years, there are many answers to these questions. The Committee for the Study of Ultrasonics in Dentistry has brought only a few of the authorities together to report on the progress already made. Today, ultrasonics offers advantages in cavity preparation, amalgam condensation, and periodontics. The future of ultrasonics in dentistry is bright. Continued research is necessary to further explore the broad use of ultrasonics, and dentistry is prepared to continue its effort.

REFERENCES

1. Catuna, M. C.: Sonic Energy: A Possible Dental Application. Preliminary Report of an Ultrasonic Cutting Method, Ann. Den. **12**:100-101, 1953.
2. Oman, C. R., and Applebaum, Edmund: Ultrasonic Cavity Preparation. Preliminary Report, New York State D. J. **20**:256-260, 1954.

College of Dentistry
The Ohio State University
Columbus 10, Ohio

EFFECTS OF ULTRASONIC CAVITY PREPARATION UPON THE PULP

HELMUT A. ZANDER, M.S., D.D.S.*
Eastman Dental Dispensary, Rochester, N. Y.

SINCE THE REPORT BY Hansen and Nielsen[1] about the possible pulp damage caused by ultrasonic cavity preparation, a great deal of work has been done on the subject of the effects of ultrasonic cavity preparation upon the pulp. Hansen and Nielsen's report was based upon research on 40 guinea pigs. They found severe pulp changes and alterations in the dentine when cuts were made with their ultrasonic instrument into the incisors of the guinea pigs, while control teeth that were cut with rotary instruments did not show such alterations.

Studies on 23 human teeth by three different authors[2, 3, 4] disagree with the findings by Hansen and Nielsen. Two of these studies were conducted on healthy teeth, with control teeth having cavities prepared in the same position and to the same depth. The ages of the patients ranged from 10 to 18 years. The cavities were filled, in one case, with calcium hydroxide and zinc oxyphosphate; and in the other case with gutta percha. Both of these studies show the same pulp response for the teeth prepared with the bur or stone as with the ultrasonic instrument. The pulpal changes range from normal pulps to slight vacuolization of the odontoblastic layer or beneath the odontoblastic layer, slight areas of hemorrhage, and some irregular dentine formation. The times of examination ranged from six days to two months in these two studies. The study by Zach[4] used zinc oxide and eugenol as a filling material and shows histologic sections of seven anterior teeth all having gingival third cavities; the time interval after cavity preparation ranged from one day to six weeks. These specimens show much the same pathology as that described by the other two authors.

A study[5] was conducted on teeth of seven monkeys, cavity preparations being made in 164 teeth. Half of the cavities were prepared under water with a rotating handpiece, and the other half were prepared with the Cavitron unit. A zinc-free amalgam was used as the filling material in these teeth; the period of observation varied from one day to two months. The results of this study agree with the results of the studies on the human teeth; no major differences in pulp pathology could be detected following ultrasonic procedures when compared with conventional cavity preparation. This study on monkey teeth was conducted blindly in that the sections of the teeth were prepared in a different place than the cavity preparations. The evaluation was made before the evaluator knew which teeth were prepared in which manner.

Read before the Symposium on Ultrasonic Dentistry, Miami Beach, Fla., Nov. 3, 1957.
Received for publication Oct. 28, 1957.
*Head, Department of Periodontology.

PULP INJURY

In order to evaluate the Cavitron unit in regard to the possibility of pulp injury due to the use of this method, one must keep in mind that cutting into the dentine with any method will produce an injury to the odontoblasts and possibly to other pulpal cells. Moreover, since cavities are always filled with a restorative material, this material too will produce a pulpal reaction. It has long been known that a heat rise in the pulp, due to mechanical preparations into the dentine, will produce the types of pulp reactions described by the four authors mentioned.[6] Zach[7] studied the thermogenic effect with the ultrasonic instrument and found a definite heat rise in the pulp which was related to the amount of pressure used with the instrument. Therefore, for all practical purposes, a very light pressure should be used with the ultrasonic equipment. The same precautions—during cavity preparation, after cavity preparation, and in the treatment of the dentine—must be observed with the ultrasonic as well as with conventional methods of cavity preparation.

CONCLUSIONS

Pulp reaction to ultrasonic cavity preparation is similar to pulp reaction to the conventional methods of preparation. No more nor less damage can be expected from this cutting tool than from rotary cutting tools, provided neither one of them is abused.

REFERENCES

1. Hansen, Louis S., and Nielsen, Arne G.: Comparison of Tissue Response to Rotary and Ultrasonic Dental Cutting Procedures, J.A.D.A. **52**:131-137, 1956.
2. Healey, H. J., Patterson, S. S., and Van Huysen, Grant: Pulp Reaction to Ultrasonic Cavity Preparation, U. S. Armed Forces M. J. **7**:685-692, 1956.
3. Mitchell, David F., and Jensen, James R.: Preliminary Report on the Reaction of the Dental Pulp to Cavity Preparation Using an Ultrasonic Device, J.A.D.A. **55**:57-62, 1957.
4. Zach, Leo, and Brown, Gregory, N.: Pulpal Effect of Ultrasonic Cavity Preparation. Preliminary Report, New York State D. J. **22**:9-17, 1956.
5. Butt, B. G., Harris, N. O., Shannon, I., and Zander, H. A.: Ultrasonic Removal of Tooth Structure. I. A Histopathologic Evaluation of Pulpal Response in Monkeys after Ultrasonic Cavity Preparation, J.A.D.A. **55**:32-36, 1957.
6. Lisanti, V. F., and Zander, H. A.: Thermal Injury to Normal Dog Teeth: In Vivo Measurements of Pulp Temperature Increases and Their Effect on the Pulp Tissue, J. D. Res. **31**:548-558, 1952.
7. Zach, Leo, Morrison, A. H., and Cohen, Gerson: Thermogenetic Effect of Ultrasonic Cavity Preparation, New York State D. J. **23**:123-127, 1957.

EASTMAN DENTAL DISPENSARY
800 MAIN STREET EAST
ROCHESTER 3, N. Y.

ULTRASONIC CAVITY PREPARATION: EFFECT ON THE IMMATURE DENTITION

LEO ZACH, D.D.S.*
New York University, College of Dentistry, New York, N. Y.

THE GROWTH OF THE REALIZATION that clinical dental treatment is founded on a basic scientific rationale has received powerful impetus by the introduction of the ultrasonic dental tool. Histopathologic evaluation of the new device, an analysis of potential tissue effects resulting from clinical use, was soon recognized by the profession as a necessity for thorough appraisal. Early reports[1, 2, 3] attested to the mechanical effectiveness of the ultrasonic tool in removing tooth substance; manipulative advantages to the operator, technical advantages in the smoothness and precision of the preparations, and human advantages in terms of lessened stress to the patient were outlined and evaluated.

The new modality of energy application to the tooth heightened the need for a biologic assay of tissue response in comparison with tissue effects produced by rotary instrument cavity preparation. Preliminary papers[4-8] were devoted to pulp studies of adult, erupted teeth in both humans and animals. Reactions were generally mild and judged reversible. A study[9] of heat flow within the pulp and at the apex of the tooth, induced by cavity preparation, indicated no thermogenesis beyond 14° F. with any device, including ultrasonics, when water coolant was used. Safe limits prevailed.

One report, however, by Hansen and Nielsen,[10] focused attention in a new direction; on the possible effect of ultrasonic preparation on extremely labile, growing dental structures. Their findings disclosed a dysplastic response, inducing distortion of amelogenesis and disruption of dentinogenesis in the continuously erupting guinea pig incisor subjected to ultrasonic cavity preparation. Though no direct homologue exists in higher animal orders, this report on a tooth of continuous growth bore implications of potential effects on the immature dentitions of children. This article is an attempt to evaluate the ultrasonic device as used in the preparation of cavities in deciduous and immature permanent teeth. It is aimed as a histologic bio-assay of ultrasonic effect on the deciduous tooth being shed, the underlying permanent tooth and its developing membranes, and the young permanent tooth with incomplete root, together with supporting and surrounding structures.

Read before the Symposium on Ultrasonic Dentistry, Miami Beach, Fla., Nov. 3, 1957.
Received for publication Oct. 16, 1957.

*Assistant Professor of Oral Pathology, Department of Pathology, New York University, College of Dentistry. Visiting Fellow, The Murry and Leonie Guggenheim Foundation Institute for Dental Research, New York University, College of Dentistry.

MATERIALS AND METHODS

Four monkeys with mixed dentition, two Rhesus and two Mangabe, were selected for study. The dental formula and individual tooth morphology of these species are identical with man in most respects, although the eruption sequence varies slightly. All animals bore permanent central and lateral incisors and first molars. Deciduous cuspids and molars were present. Both Mangabe monkeys presented the cuspal tips of the maxillary second molars, but a bridge of mucosa still covered most of the occlusal surfaces.

The animals were anesthetized and either Class I or Class V cavities were prepared at least 1.5 mm. into dentin, by either the ultrasonic device* or rotary instruments at 12,600 r.p.m., with water-spray coolant. A new Cavitip was used for every two ultrasonic preparations, and a fresh No. 557 fissure bur was used for each rotary preparation. Average tooth-contact time ranged from 15 to 30 seconds; the water-spray coolant or abrasive solution was removed with an aspirator. Clinically effective operating pressures, measured with spring balances, were used, ranging from 2 to 3 ounces with ultrasonic and 6 to 8 ounces with the bur. Several pulp exposures were inadvertently produced in deciduous teeth.

Three quadrants in each animal received ultrasonic preparations with the fourth quadrant serving as control. In the fourth quadrant, 2 teeth were left unoperated, and the remainder were prepared with burs. A total of 98 teeth examined produced 64 interpretable sections.

After preparation, the cavities were filled with zinc oxide and eugenol cement. Two animals were sacrificed after 1 week, and one each after 1- and 2-month intervals. Fixation was achieved by perfusion with Bouin's solution after which the entire maxillae and mandible were placed in the same fixative for 3 additional days. After slow decalcification, paraffin sections at 6 micra were prepared and stained with hematoxylin and eosin.

HISTOLOGIC FINDINGS

Of 64 sections deemed visually reliable for histologic observation, 49 received ultrasonic cavity preparations, 10 bore rotary instrument preparations, and 5 were untreated controls. Illustrations of representative sections follow.

An archetypal section is reproduced in Fig. 1, a mandibular deciduous incisor with associated developing permanent incisor in a Rhesus monkey. This control section illustrates the extent of en bloc sections and the generally hyperemic condition of the pulp produced by the pressure-perfusion technique.

In Fig. 2, the effects of an ultrasonic cavity preparation on a deciduous Rhesus cuspid showing lingual root resorption (*RR*) and the presence of both lateral incisor (obliquely sectioned) and cuspid follicles are evident. The cavity preparation in this 30-day postpreparation specimen is moderately deep (*CP*), but no pulpal reaction other than perfusion-induced hyperemia, evident in control sections, is manifest. The more apical portions of pulp (*AP*) show some fixation artifact, but the area of the foramen (*AF*) and developing cuspid bud,

*Cavitron Model 210.

magnified in Fig. 3, shows no aberration. Here the integrity of the deciduous pulp in the apical foramen area (*AF*) is well maintained; the little terminal spur of dentin (*TS*) is well held as early resorption is evidenced by a lining up of osteoclast-like cells. Terminal alveolar bone (*AB*) is unmarred, as are the hard and soft elements of the developing tooth. Here, outer enamel epithelium (*OE*) and stellate reticulum (*SR*), compressed above, are present below the downward plunging spikes of forming enamel and dentin at point *X*. Ameloblasts (*A*), Hertwig's membrane (*HM*), and odontoblasts (*O*) are undisturbed, as is the embryonal pulp (*EP*).

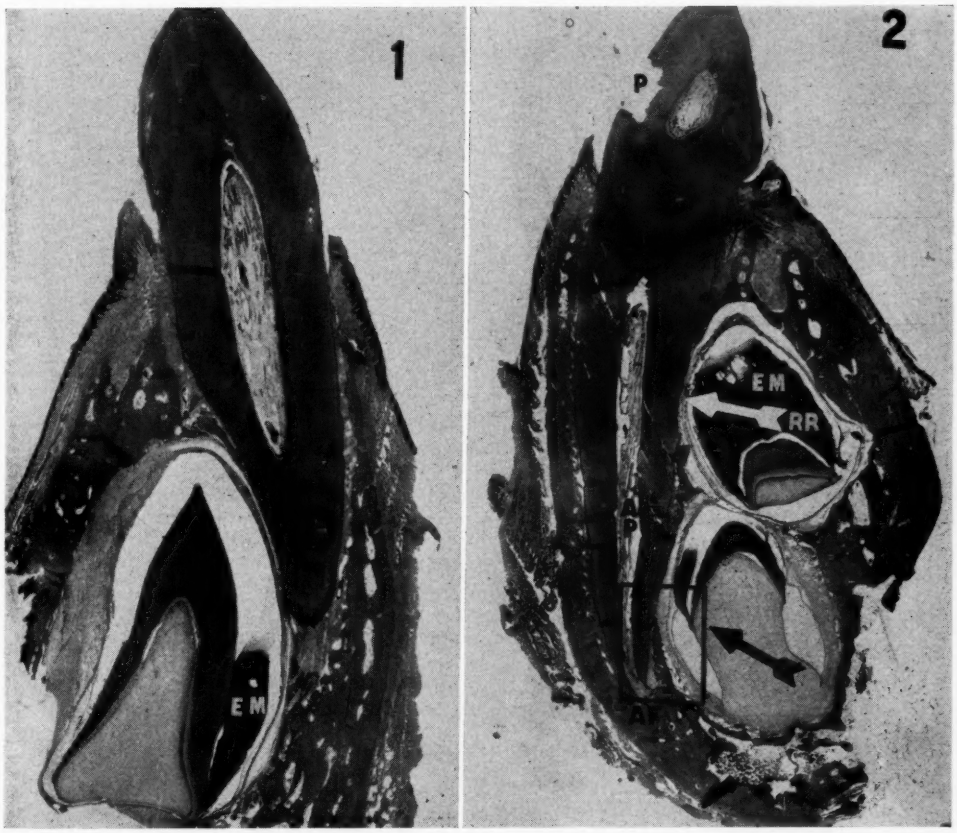


Fig. 1.—A control specimen shows the typical specimen studied; a deciduous tooth in situ, with all supporting, covering, and adjacent structures present, and developing permanent tooth below. Enamel matrix (*E*) is retained by careful, slow decalcification.

Fig. 2.—A specimen with an ultrasonic cavity preparation (*CP*) shows early root resorption (*RR*) and a normal pulp in a 30-day specimen. Apical foramen area (*AF*) is unaltered. Two permanent buds are present. The box indicates the area of Fig. 3.

A portion of root surface and adnexa of a freshly erupted, not yet occluding maxillary second molar, bearing a 30-day ultrasonic preparation, is seen in Fig. 4. Many shreds of the root contour delineating Hertwig's sheath persist as minute

Fig. 3.—A higher power demonstrates the preserved structural integrity of the apical foramen (*AF*), alveolar bone (*AB*), and a terminal spur of dentin (*TS*). The developing bud shows normal outer enamel epithelium (*OE*), stellate reticulum (*SR*), Hertwig's membrane (*HM*), and embryonal pulp (*EP*). Ameloblasts (*A*) and odontoblasts (*O*) are in normal state.

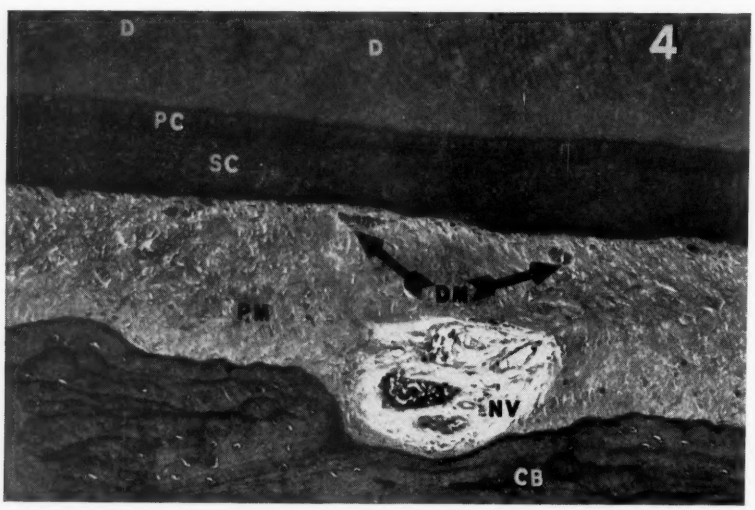


Fig. 4.—This section of the root wall demonstrates the wide periodontal membrane (*PM*) and cortical plate (*CB*) of a young molar bearing a 30-day ultrasonic preparation. The epithelial remnants of Hertwig's sheath, the debris of Malassez (*DM*) show no hyperplasia within the periodontal membrane (*PM*). Cementum (*PC, SC*) and neurovascular channel (*NV*) are normal.

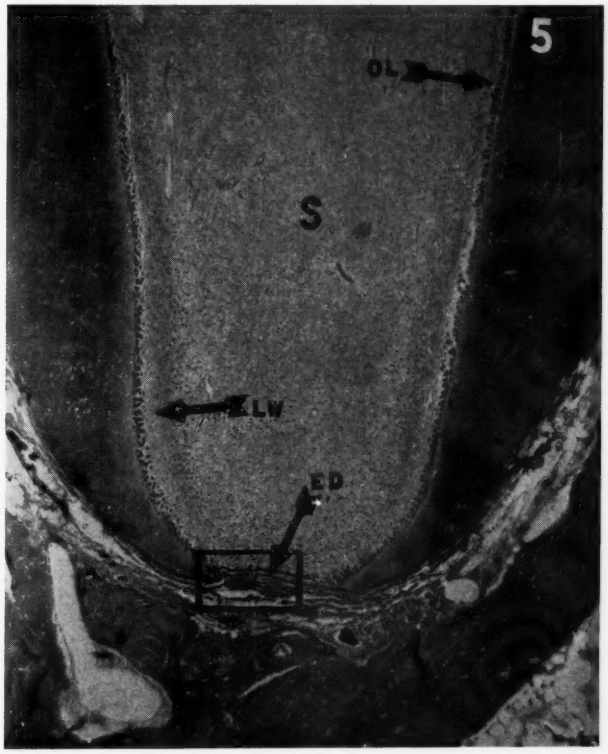


Fig. 5.—The apical area of the same specimen as in Fig. 4; here the epithelial diaphragm (*ED*), normal and intact, is boxed for enlargement in Fig. 6. The odontoblasts (*OL*) lining the pulp are undisturbed and the reactive layer of Weil (*LW*) is normally cell-free. The stroma (*S*) is rich in embryonal cells and delicate nerve filaments.

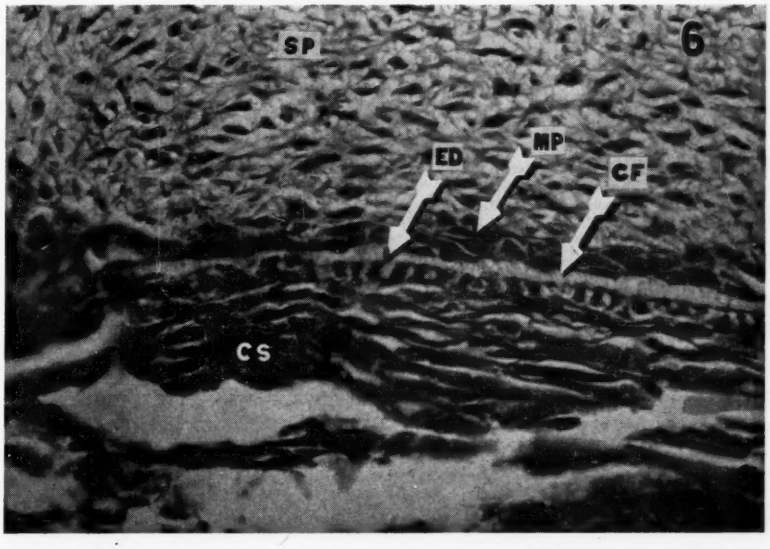


Fig. 6.—High-power shows the intimate details of the pulp-limiting epithelial diaphragm (*ED*) with the cell-free zone (*CF*) and compacted modified pre-odontoblasts (*MP*) intact despite ultrasonic preparation. The strong collagenous sheath (*CS*) below the wide apex is normal.

epithelial rosettes (debris of Malassez, *DM*) within the wide, unstressed periodontal membrane (*PM*). No stimulation of these potentially cyst-forming buds is evident. The nerve and blood vessel trunk (*NV*), both primary (*PC*) and secondary (*SC*) cementum which bear no lacunae, and cortical plate bone (*CB*) are unmarred. The wide, immature apical pulp of a 7-day postpreparation incisor is shown in Fig. 5 to possess a complete, intact epithelial diaphragm (*ED*) and a normal odontoblast layer (*OL*). The stroma (*S*) is cell-rich and the matrix is reticular. The cell-free layer of Weil is clear and undisturbed (*LW*). Fig. 6, a

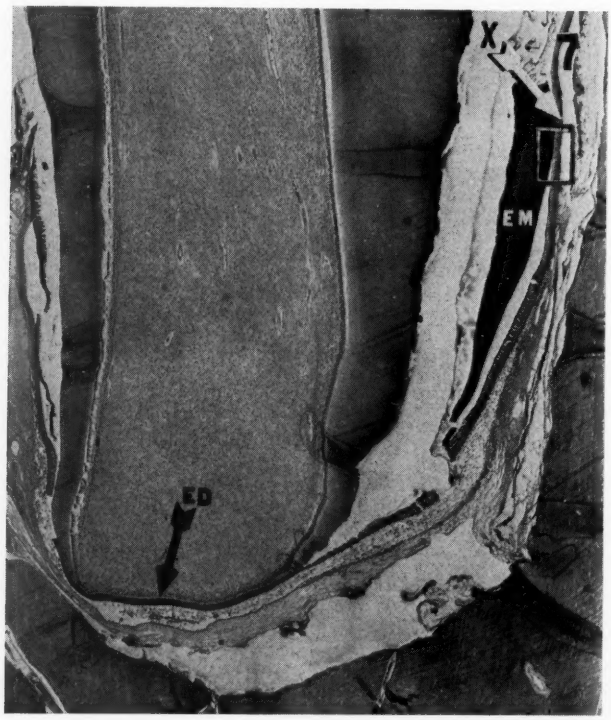


Fig. 7.—Epithelial diaphragm (*ED*) of a cuspid just having completed crown formation is seen with some retained enamel matrix (*EM*). The boxed area in this 60-day postpreparation specimen (ultrasonic) is shown in high power in Fig. 8.

higher magnification of the boxed area in Fig. 5, shows the cuboidal cell pattern of the epithelial diaphragm (*ED*), the tough-fibered collagenous sheath below (*CS*), the cell-free strip (*CF*), and the modified, packed mesenchymal cells of pulp directly above (*MP*). These delicate structures together with the stellate pulp cells (*SP*) are seen to be unaltered and in normal developmental state.

In Fig. 7, the developing apical end of a mandibular cuspid is seen (despite some shrinkage in preparation) to contain an intact epithelial diaphragm (*ED*) and a portion of enamel matrix (*EM*). The overlying deciduous cuspid bears an ultrasonic cavity placed 60 days before sacrifice. High power of the boxed area (*X*) demonstrates normal amelogenesis in Fig. 8. Stratum intermedium (*SI*) adheres to the ameloblasts which show nuclear polarization (*NP*). Terminal

bar apparatus is seen in the lifted cells (*TB*) and fairly regular prismatic structure of enamel, normal and undisturbed, is evident (*E*).

The sections studied revealed no discernible differences in the normal, unaltered developing structures after ultrasonic preparation, rotary preparation, or no preparation. There was no dysplasia or disruption of wide apices, extending membranes were apparently unaffected, and deciduous resorption showed no change from normal. Pulp reaction in both deciduous and young permanent teeth showed the mild "defensive and reparative"[11] changes completely analagous to the pulp responses seen in adult teeth subject to cavity preparation.

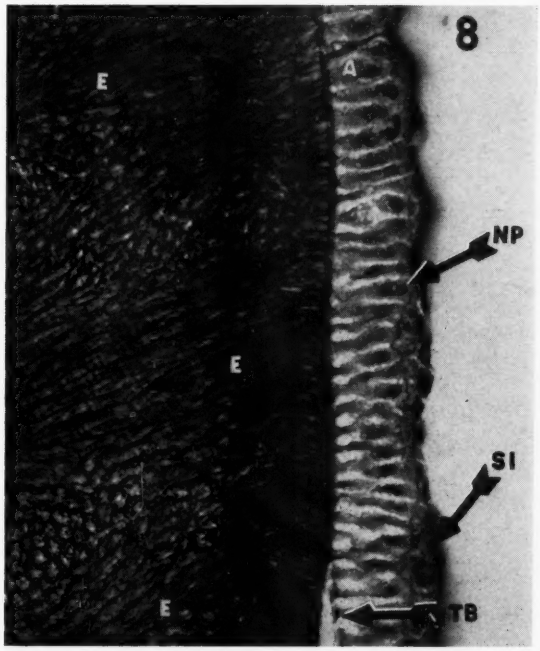


Fig. 8.—Normal amelogenesis is apparent in this section with terminal bar apparatus (*TB*) and nuclear polarity (*NP*) normal. The stratum intermedium (*SI*) mantles the actively secreting ameloblasts (*A*). Enamel prisms (*E*) are normal and well-formed.

CONCLUSION

Under the conditions of this investigation, ultrasonic cavity preparation has no deleterious effect upon the apical tissues of forming teeth. Ultrasonic energy applied to deciduous teeth causes no injury in the partially formed developing permanent successor.

REFERENCES

1. Oman, C. R., and Applebaum, E.: Ultrasonic Cavity Preparation. Preliminary Report, New York State D. J. **20**:256-260, 1954.
2. Oman, C. R., and Applebaum, E.: Ultrasonic Cavity Preparation. II. Progress Report, J.A.D.A. **50**:414-417, 1955.
3. Zinner, D. D., and Whetstone, W. L.: Ultrasonic Dental Unit in Pedodontics, J. Den. Children **23**:3-12, 1956.

4. Zach, L., and Brown, G. N.: Pulpal Effect of Ultrasonic Cavity Preparation. Preliminary Report, New York State D. J. **22**:9-17, 1956.
5. Healey, H. J., Patterson, S. S., and van Huysen, G.: Pulp Reaction to Ultrasonic Cavity Preparation. Preliminary Report, U. S. Armed Forces Med. J. **7**:685-692, 1956.
6. Friedman, J., Lite, T., and Solomon, H.: Pulp Reactions to Ultrasonic Tooth Preparation, New York J. Den **26**:144-148, 1956.
7. Mitchell, D. F., and Jensen, J. R.: Preliminary Report on the Reaction of the Dental Pulp to Cavity Preparation Using an Ultrasonic Device, J.A.D.A **55**:57-62, 1957.
8. Butt, B. G., Harris, N. O., Shannon, I., and Zander, H. A.: Ultrasonic Removal of Tooth Structure. 1. A Histopathologic Evaluation of Pulpal Response in Monkeys After Ultrasonic Cavity Preparation, J.A.D.A. **55**:32-36, 1957.
9. Zach, L., Morrison, A. H., and Cohen, G.: Thermogenetic Effect of Ultrasonic Cavity Preparation, New York State D. J. **23**:123-27, 1957.
10. Hansen, L. S., and Nielsen, A. G.: Comparison of Tissue Response to Rotary and Ultrasonic Dental Cutting Procedures, J.A.D.A. **52**:131-137, 1956.
11. James, V. E., Schour, I., and Spence, J. M.: Response of Human Pulp to Gutta-percha and Cavity Preparation, J.A.D.A. **49**:639, 1954.

209 E. 23RD ST.
NEW YORK 10, N. Y.

THE EFFECT OF ULTRASONIC ENERGY ON THE PERIODONTAL MEMBRANE, ALVEOLAR BONE, AND GINGIVAE

ROLLIN E. MALLERNEE, D.D.S., M.Sc.*
College of Medical Evangelists, School of Dentistry, Loma Linda, Calif.

THE ADAPTATION OF ULTRASONIC energy for dental instrumentation has had a profound effect on the profession and the public. Since its introduction in 1953, many investigators have studied and reported the pulpal response of cavity preparation with ultrasonic energy.[1-6]

Ultrasonic energy has been used for intra- and extracoronal preparations, root canal therapy, periodontics, and condensing amalgam, with little, if any, attempt to determine whether or not there is damage to the periodontal membrane and alveolar bone. Pulpal injury has been the standard for determining the safety of techniques and materials used upon the teeth. The adnexa should be given equal consideration. They are highly specialized organs and are vital to the maintenance of a healthy dentition. Injury to the investing tissues may result in the early and unnecessary loss of teeth.

The application of ultrasonic energy to the teeth for any purpose is assumed to cause vibrations of the teeth. If true, the vibrations may be transmitted to the periodontal membrane and through it to the alveolar bone. It was the purpose of this study to determine whether or not such ultrasonic vibrations, if transmitted, had any adverse effect upon the periodontal membrane, alveolar bone, or gingivae.

METHODS AND MATERIALS

The teeth of young dogs were used for the experiment because their size and investing tissues are similar to those of humans. The total number of teeth available were divided into three groups. Group I consisted of 33 teeth in which cavities were prepared with an ultrasonic device. The average cavity depth was 1.5 mm. Each cavity was filled with zinc oxide and eugenol cement.

Group II consisted of 28 teeth which were subjected to scaling procedures with ultrasonic energy. A Bunting file, which had been adapted to the ultrasonic instrument, was placed gently against all of the exposed surfaces of the teeth, supragingivally and subgingivally, in a sweeping motion, while a stream of water flowed against the tip. The application to each tooth was continuous and lasted two minutes.

Group III consisted of 36 teeth which remained untreated and served as controls.

Read before the Symposium on Ultrasonic Dentistry, Miami Beach, Fla., Nov. 3, 1957.
Received for publication Oct. 21, 1957.
*Department of Periodontology.

In two of the animals, the teeth in one quadrant of the mouth were used for ultrasonic cavity preparations, those in another quadrant were used for ultrasonic scaling procedures, and those in a third quadrant served as controls. In each quadrant, teeth were selected at random for 24-hour, 7-day, and 28-day intervals between the time of the operative procedures and the time the animals were sacrificed. In this manner, one tooth may have been a 28-day specimen, while the teeth on either side of it could have been 28-day, 7-day, or 24-hour specimens, much as one would expect to find in human mouths subjected to dental treatment.

Fig. 1.—A photomicrograph of a section showing the apex of tooth, periodontal membrane, and alveolar bone of a control specimen.

In the remaining two animals, the teeth in one segment of the jaws were subjected to the *same* type of treatment for the arbitrarily selected postoperative periods. The periodontal membranes and surrounding tissues could then be studied in areas that had been exposed to the same type of energy and for the same postoperative intervals.

Specimens were taken prior to sacrificing the animals. Longitudinal serial sections were cut buccolingually or mesiodistally and stained with hematoxylin and eosin.

All elements of the periodontal membrane, alveolar bone, and gingivae that are visible under an optical microscope were studied. In the dog, the principal fibers of the periodontal membrane may be seen passing from the cementum to the alveolar bone, gingivae, or adjacent teeth. The fibers are grouped into generally well-defined bundles, some of which are rather coarse in appearance. The tissue is abundantly supplied with blood vessels, nerves, and lymphatics (Fig. 1).

The alveolar bone proper, with the embedded fibers, the compact and spongy bone, the bone marrow, the gingivae, and crevicular epithelium are similar to human tissue.

Fig. 2.

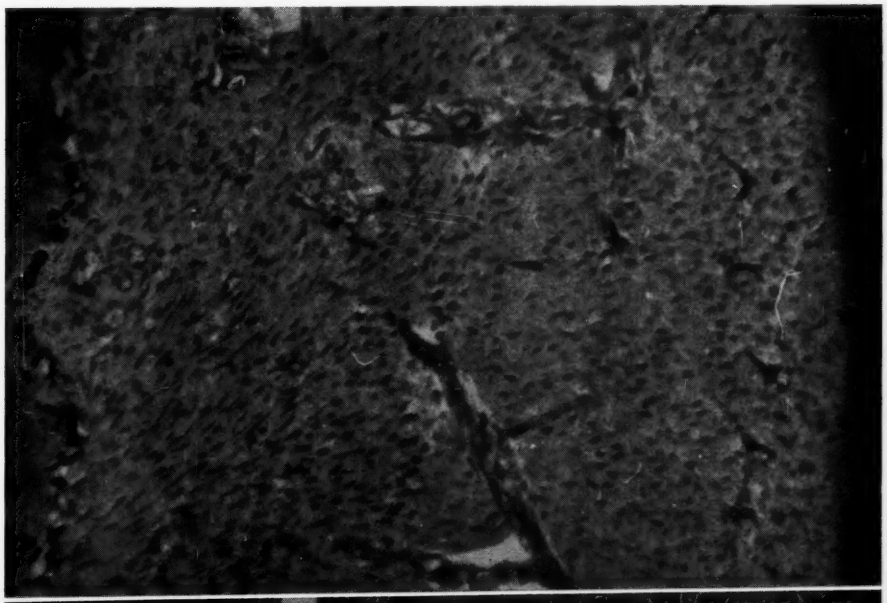


Fig. 3.

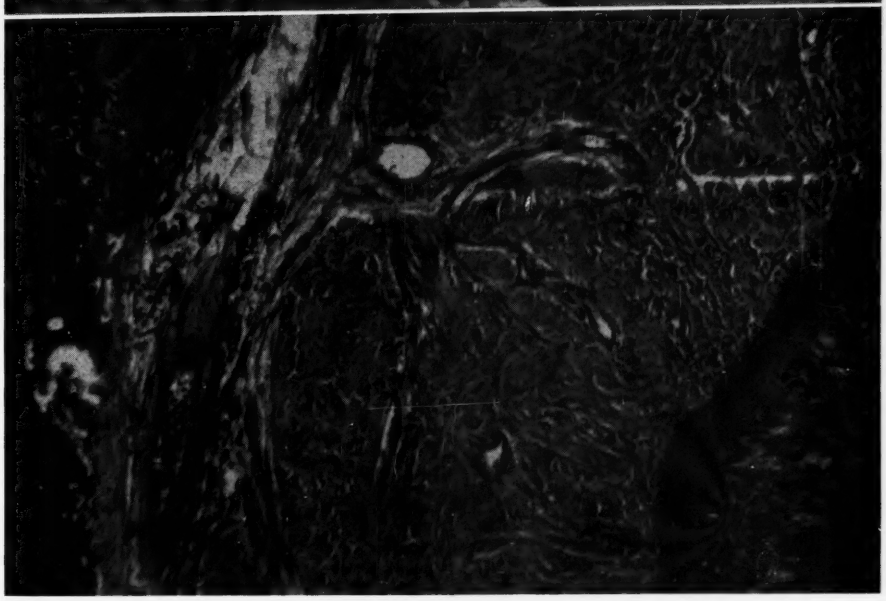


Fig. 2.—A photomicrograph of the area near the crest of the alveolus of a tooth in which a cavity had been prepared ultrasonically 24 hours before the animal was sacrificed.

Fig. 3.—An area near the apex of a tooth treated as in Fig. 2.

RESULTS AND DISCUSSION

Microscopic examination of sections of the experimental tissue showed no abnormal variation from the controls. Serial longitudinal sections permitted complete study of the periodontal membrane from the free gingivae to the apical fibers. There was no evidence of atrophy or loss of fibers. The absence of inflammatory cells indicated that no injury had occurred. The alveolar bone was similarly undisturbed. The crest of the alveolus, the true alveolar and the supporting bone contained osteocytes. No resorption was evident except that which had occurred normally as a result of tooth movement, which was also present in the control section. The bone marrow was also normal. Examination of the gingivae and crevicular epithelium in Groups I and II were also normal. Evidence of burns, such as vesicles and the associated inflammatory exudate, was completely lacking.

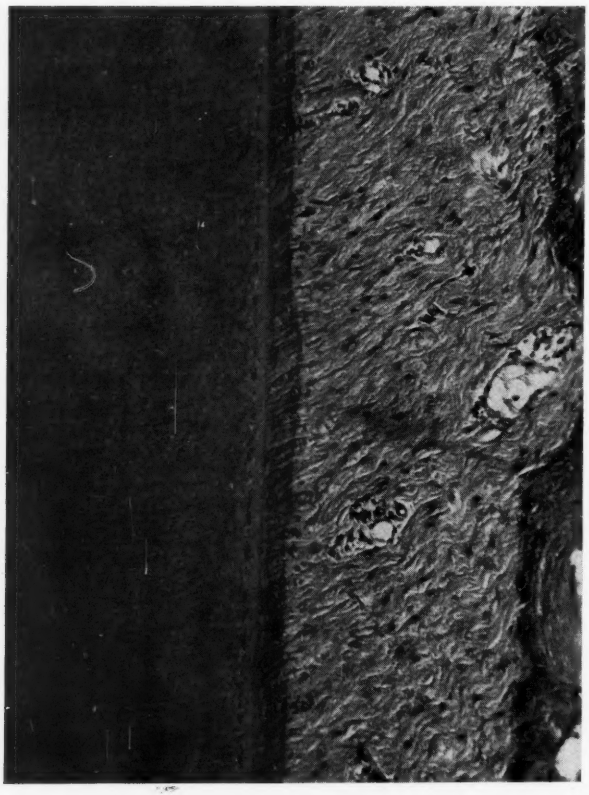


Fig. 4.—A photomicrograph showing an area near the alveolar crest of a tooth scaled ultrasonically for 2 minutes 7 days prior to sacrificing.

The photomicrograph shown in Fig. 2 is of a section taken from the area of the crest of the alveolus of a tooth in which a cavity had been prepared with an ultrasonic dental instrument 24 hours prior to sacrificing. Fig. 3 is from an area near the apex of a similarly treated tooth. There is no evident cellular degeneration, fibrillar change, or inflammation. The periodontal membrane and alveolar bone are normal.

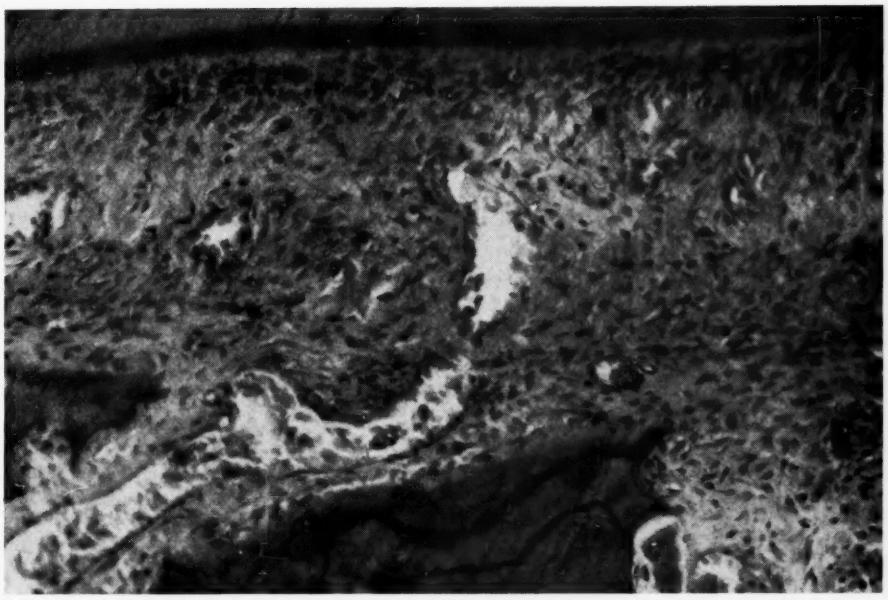


Fig. 5.—An area near the apex of a tooth that was treated as in Fig. 4.

Fig. 6.—Photomicrograph showing the gingival sulcus and adjacent periodontal membrane of a tooth scaled ultrasonically for 2 minutes 24 hours before sacrificing.

Fig. 4 shows an area near the alveolar crest adjacent to a tooth that had been scaled for two minutes with an ultrasonic instrument. An area near the apex of a similarly treated tooth is shown in Fig. 5. No cellular damage was evident. The appearance of the fibers, fiber bundles, and alveolar bone is similar to that seen in the control sections. Fig. 6 is a photomicrograph of the gingivae and sulcus of a tooth scaled with an ultrasonic instrument. There is no evidence of vesicle formation as the result of burns. There is no inflammatory exudate. Leukocytes and plasma cells were seen occasionally in the surrounding connective tissue at the bottom of the gingival sulcus but no more frequently than in the controls.[7]

No evidence is available to date that ultrasonic vibrations are set up in teeth and their surrounding tissues by ultrasonic dental instruments. While such vibration is conceivable, its significance may be established by evidence of injury.

The techniques of ultrasonic cavity preparation and periodontal therapy are based upon the loose coupling of the ultrasonic device. The absence of evidence of injury, manifested either in the mild form of a transudate or a slight increase in polymorphonuclear neutrophiles, is significant. It establishes that the correct and effective use of ultrasonic energy will not produce harmful energy waves in the tissues surrounding the teeth.

If it was present, the concentration of energy at interfaces of the supporting tissues was of such a low magnitude that no histologic evidence of injury was observed. Contact of the vibrating scaler and water stream with the soft tissue, crevicular epithelium, and gingivae produced no histologic or clinical evidence of a burn. Previous experiments[8] have shown that direct applications of the vibrating tip of an ultrasonic dental instrument have had no injurious effects upon capillaries and small blood vessels.

CONCLUSION

The use of ultrasonic energy to prepare cavities and for scaling of teeth, as used in this experiment, is not injurious to the periodontal membrane, alveolar bone, or gingivae.

REFERENCES

1. Hansen, L. S., and Nielsen, A. G.: Comparison of Tissue Response to Rotary and Ultrasonic Dental Cutting Procedures, J.A.D.A. **52**:131, 1956.
2. Zach, L., and Brown, G. N.: Pulpal Effect of Ultrasonic Cavity Preparation. Preliminary Report, New York State D. J. **22**:9-17, 1956.
3. Butt, B. G., Harris, N. O., Shannon, I. L., and Zander, H. A.: Histopathological Evaluation of Pulpal Response to Ultrasonic Cavity Preparation, I.A.D.R. Preprinted Abstract No. 34, March, 1956.
4. Friedman, J., Lite, T., and Solomon, H.: Pulp Reactions to Ultrasonic Tooth Preparation, New York J. Den. **26**:144, 1956.
5. Healey, H. J., Patterson, S. S., and Van Huysen, G.: Pulp Reaction to Ultrasonic Cavity Preparation. Preliminary Report, U. S. Armed Forces M. J. **7**:685, 1956.
6. Robinson, H. B. G.: Pulpal Effects of Operative Dentistry, J. Pros. Den. **7**:282, 1957.
7. Orban, B. J.: Oral Histology and Embryology, ed. 4, St. Louis, 1957, The C. V. Mosby Co.
8. Lessler, M. A., and Mallernee, R. E.: The Effect of Dental Ultrasonic Energy on Lingual Tissue. Oral Presentation, International Conference on Ultrasonics in Medicine, Los Angeles, Calif., Sept., 1957.

College of Medical Evangelists
School of Dentistry
Loma Linda, Calif.

ULTRASONIC CAVITY PREPARATION

HARRY H. POSTLE, D.D.S.*
The Ohio State University, College of Dentistry, Columbus, Ohio

HISTORICALLY, THE DENTAL PROFESSION has bent every effort to make operative procedures more tolerable to patients. In the effort to attain this goal, many advances have been made. Higher rotational speeds, airbrasive, and ultrasonic techniques have been advocated as less discomforting methods of cavity preparation. The introduction of new equipment places a responsibility upon dentistry to determine its merit and, if worthy, incorporate its use into general practice.

The ultrasonic instrument is no longer in the experimental stage. The safety of the instrument has been well established by many investigators.[1-13] It is well known that this instrument will cut sound tooth structure effectively and provide smooth surfaces and sharp line and point angles.[14, 15] Patients tolerate the instrument well and require local anesthesia infrequently.[13] This being true, it is now dentistry's obligation to develop skills and techniques in its use so that the profession may take advantage of this new cutting device. This report is intended to illustrate some of the technical advantages of the ultrasonic instrument.

Cavity preparation with the ultrasonic dental unit is attained by two distinct actions: thrusting and planing. The "thrusting" action consists of removing enamel and dentin with the nib surface of the Cavitip (the working point) which is vibrated into the tooth in the direction of the blade of the instrument (Fig. 1). The thrusting action is extremely effective.

The "planing" action consists of extending the walls already established by the initial thrust (Fig. 2). The planing and extending action has recently been greatly enhanced by an off-angle Cavitip design. Both thrusting and planing make it possible to complete all classes of cavity preparation with facility.

INSTRUMENT MANIPULATION

Manipulation of the ultrasonic instrument differs from that for the standard rotary handpiece. While it is not difficult to master, its use requires a thorough knowledge of the instrument, coupled with a reasonable practice or learning period. Attempts to use this instrument as a standard rotary handpiece are disappointing, and failure results. It should be used with light hand pressure, just enough pressure to guide the instrument. If a greater load is applied, cutting effectiveness is reduced, and pain, noise, and heat will result.

Read before the Symposium on Ultrasonic Dentistry, Miami Beach, Fla., Nov. 3, 1957.
Received for publication Oct. 16, 1957.
*Assistant Professor, Department of Operative Dentistry.

The movement of the tip during cutting is extremely important. The instrument should be kept in slow, steady, constant motion, allowing time for the cutting action to take place.

Whenever possible, direct vision is used because the abrasive solution coats the mirror. Direct vision is no problem in the lower arch, and in the upper arch it can be accomplished by raising the chair and tilting the patient's head backwards. With a little practice this technique can easily be mastered (see Fig. 25).

INDICATIONS FOR USE

The ultrasonic instrument is indicated for cutting sound tooth structure. This means that all standard "Black" classes of cavity preparations can be done with the ultrasonic technique. Best results are obtained when caries are not extensive, and when existing restorations, if present, are of minimal size. Amalgam is cut readily, but gold and plastic materials cannot be removed by means of the ultrasonic technique. Preparations for all types of restorative material can be made, such as for the gold inlay, amalgam, silicate, gold foil, and plastic restorations. Additional instrumentation is seldom necessary.

ADVANTAGES

The most significant advantage of ultrasonic cavity preparation is that operative procedures are more tolerable to patients. By minimizing heat, pressure, vibrations, and bone-conducted noise, patients are relaxed and less apprehensive. Pain is greatly reduced, but not completely absent. Most patients will tolerate ultrasonic preparation without anesthesia.[13]

Cavity preparation is easier and more relaxing for the dentist because the patient is at ease, and no physical force is needed to guide the instrument through the tooth.

The preparation of classical cavity forms, as described by Black* is readily accomplished. In many areas, the desired shape of the cavity is built into the instrument and, because of its precise and accurate cutting characteristic, the desirable result ensues. The finished cavity surface is smooth, requiring no additional instrumentation.

*G. V. Black.

Fig. 1.—Thrusting action using nib end of the Cavitip in the plane of the blade.

Fig. 2.—Planing and extending action, using the sides of the Cavitip.

Fig. 3.—Thrusting action of Cavitip illustrating the "eye" measurement of depth.

Fig. 4.—Planing action extending through the fissure and grooves and establishing resistance and outline form. *Insert,* The off-angle cylinder which is equally efficient.

Fig. 5.—The hollow square Cavitip thrust to the proper depth for buccal or lingual extension illustrates the fulcrum for the rotation of the instrument to form the proper divergence.

Fig. 6.—The occlusal portion of a Class II, DO preparation. The distal portion is widened and extended to include two-thirds of the marginal ridge, exposing the dentino-enamel junction.

Fig. 7.—The tapered concavo-convex inlay Cavitip is thrust to the proper gingival depth. The sides of the Cavitip are used to plane the buccal and lingual walls.

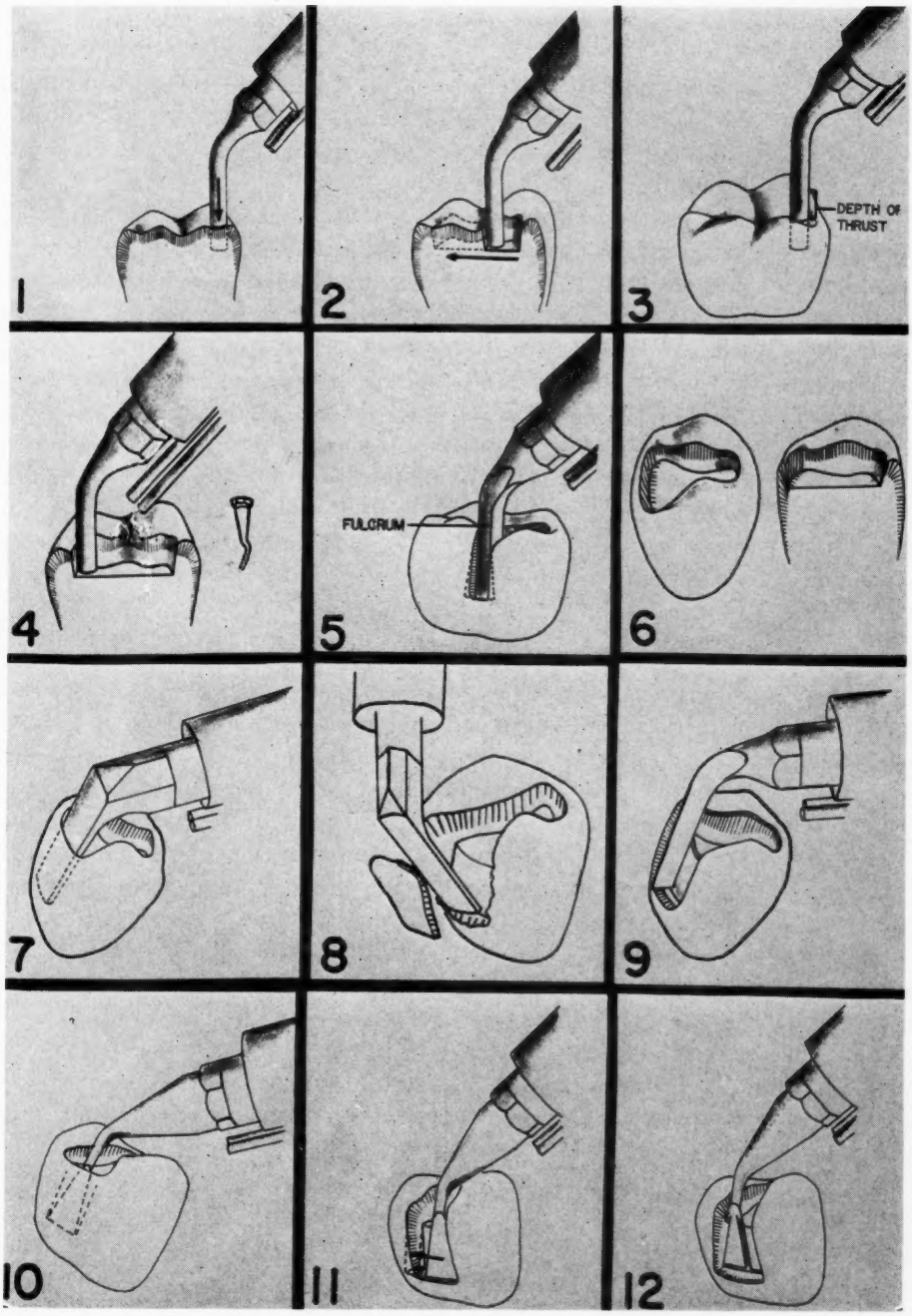
Fig. 8.—The undermined proximal enamel is fractured away with the Cavitip.

Fig. 9.—The beveled Cavitip is used for producing the gingival cavo-surface bevel, and the axiopulpal bevel.

Fig. 10.—The inverted tapered concavo-convex amalgam Cavitip is thrust to the proper gingival depth.

Fig. 11.—Planing the buccal and lingual walls with the sides of the Cavitip to produce the desired divergence.

Fig. 12.—Producing mechanical retention by moving the beveled inverted concavo-convex Cavitip into the axio-buccal, axio-gingival, and axio-lingual line angles.



Figs. 1—12. *(For legends see opposite page.)*

CLASS I PREPARATION

The Class I preparation is made easily with the ultrasonic instrument.* The cylindrical Cavitip is applied to the mesial fossa or any other weakened occlusal area. The dentist, using intermittent light load, allows the Cavitip to penetrate to the desired depth (Fig. 3). Using the same light intermittent load, the instrument is then moved laterally to remove fissures and grooves and establish the proper resistance and outline forms (Fig. 4).

For gold inlays, cavity wall divergence is easily accomplished by the proper angling of the Cavitip during preparation. Cavo-surface bevels are made with the same Cavitip. If acute angles are desired for amalgam or gold foil restorations, an inverted cone Cavitip is used. Hand spoon excavators effectively remove any remaining soft caries.

Buccal and lingual extensions can be made either with a cylindrical or a hollow square Cavitip. It is permitted to penetrate from the occlusal surface just beyond the depth of the groove. For the amalgam restoration, the Cavitip is then rocked, using the occlusal angle as a fulcrum to produce walls diverging toward the gingival margin (Fig. 5). Mechanical retention is then established and will be described under Class II amalgam preparations (Fig. 12). For inlay preparations the pendulum motion is reversed to produce tapering walls.

CLASS II PREPARATIONS

A disto-occlusal preparation on a bicuspid will be used to illustrate the technique. The standard technique of preparing the occlusal portion first is followed. During the planing and cutting operation, the distal wall is extended to include about two-thirds of the marginal ridge, exposing the dentino-enamel junction (Fig. 6).

For an inlay preparation, the proximal portion is prepared with a tapered curved Cavitip. Fabricated in graduated sizes, these concavo-convex tips produce buccal and lingual walls with 5 degree divergence toward the occlusal surface and provide a convex axial wall concentric with the dentino-enamel junction. The Cavitip is placed at the dentino-enamel junction in a vertical position and thrust gingivally along the dentino-enamel junction to the desired depth (Fig. 7). The Cavitip is then moved proximally to cleave the enamel (Fig. 8). The sides of the Cavitip are used to plane the buccal, lingual, and gingival walls. A cylindrical Cavitip is used to provide smooth continuation of proximal and occlusal walls. The same instrument is used for the occlusal cavo-surface bevel. The gingival cavo-surface bevel and the axio-pulpal bevel are attained with a hand gingival marginal trimmer or with a Cavitip (Fig. 9). The resultant cavity form presents an ideal inlay preparation.

For an amalgam preparation, the proximal portion is prepared with an inverted tapered concavo-convex Cavitip. The Cavitip is placed at the dentino-enamel junction and thrust to the correct depth, producing a rectangular trough (Fig. 10). The proximal surface of the tooth is removed by moving the Cavitip proximally.

*Cavitron.

This cleaves the enamel (Fig. 8). The sides of the Cavitip are used to plane the buccal and lingual walls, thereby producing the necessary divergence (Fig. 11). A beveled Cavitip moved into the axio-buccal, axio-gingival, and axio-lingual line angles provides mechanical retention (Fig. 12). The axio-pulpal and gingival cavo-surface bevels may be prepared as previously described. The completed preparation meets the requirements for the ideal Class II amalgam preparation.

ALTERNATE CLASS II TECHNIQUE

Another technique permits the preparation of the entire Class II with a rectangular bladed off-angle Cavitip. The occlusal portion is prepared first (Figs. 13 and 14). It is then vibrated to the desired depth on the proximal surface (Figs. 15 and 16) and extended to cleave the proximal enamel (Fig. 8). Holding the handpiece at the desired angle will produce a satisfactory proximal box for either the amalgam (Fig. 17) or the inlay preparation (Fig. 18). All proximal walls may be planed with the same instrument. It will also provide mechanical retention for the amalgam by grinding bevels on the blade (Fig. 12).

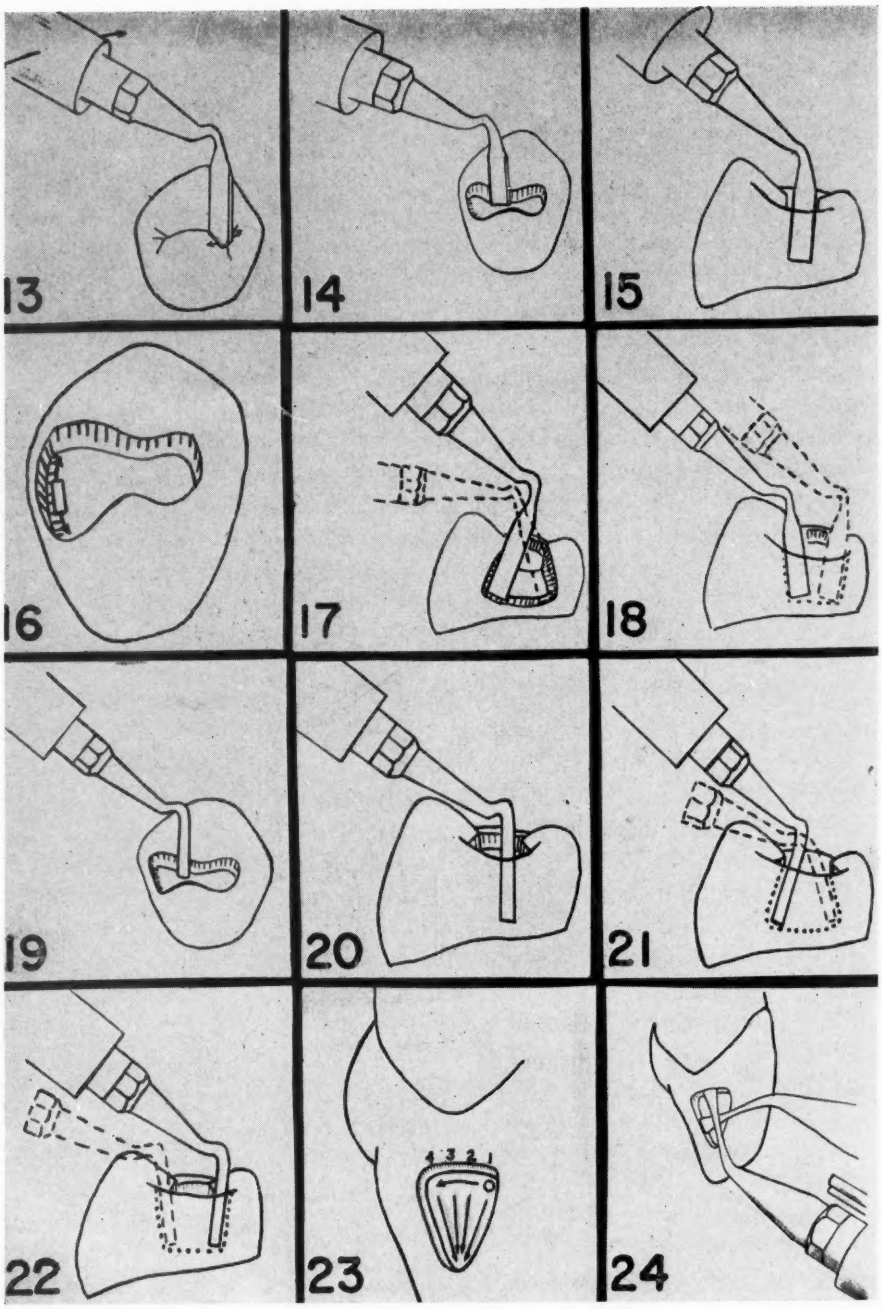
The Class II cavity may also be completed with an off-angle cylindrical Cavitip. This instrument will prepare the occlusal portion rapidly and effectively (Fig. 19). As in other techniques, the Cavitip is thrust to depth at the proximal surface (Fig. 20) and moved to produce the desired divergence in the cavity for an amalgam restoration (Fig. 21) or an inlay (Fig. 22). The proximal portion is then cleaved, and the walls are planed with the same instrument. In the case of the amalgam preparation, the mechanical retention in the proximal box may be made by utilizing rounded line angles.

The cavity for a Class III proximal silicate restoration may be completely prepared with a cylindrical Cavitip. The adjacent tooth is protected by a metal strip. The Cavitip is thrust to the desired depth and then moved from the gingival margin toward the incisal angle or vice versa. The positions of the incisal angle and labio-gingival line angles are thus established. The planing action is then continued lingually (Fig. 23) to establish the lingual and gingival walls and complete the triangular outline form of the cavity. Then the labial enamel is planed in the direction of the enamel rods. The operation is completed with a cylindrical Cavitip establishing the desired rounded retention at the incisal angle and axio-gingival line angle. The nib surface of an inverted cone Cavitip may be used to prepare the lingual and gingival enamel in the direction of the enamel rods (Fig. 24). These flares may be made with hand instruments.

The preparation just described, with some slight modifications and additional use of hand instruments, can easily be modified to make the classic Class III gold foil preparation.

CLASS III, IV, AND V PREPARATIONS

Class III and Class IV inlay preparations are modifications of the Class II preparation. The thin-bladed rectangular off-angle Cavitip is used in making the proximal portion of the preparation. The Class V gingival cavity is prepared similar to the Class I or occlusal cavity. Small cervical preparations may be pre-



(Figs. 13-24. *(For legends see opposite page.)*

pared by a thrusting action. The same instrument will finish the enamel walls properly by changing the angle of the handpiece (Fig. 25).

Fig. 25.—The hand and instrument position for direct vision operations on maxillary posterior teeth.

Recent developments in the design of Cavitips have increased the effectiveness of the ultrasonic instrument and reduced the time required in cavity preparation. The new fast-cutting instruments have made it possible to complete the average cavity preparation with one or two instruments. These are off-angle Cavitips which are effective in thrusting and planing actions. A single Cavitip, capable of both actions, may be used to complete all classes of cavities when it is used in the hands of an experienced dentist.

Fig. 13.—An alternate technique for preparing the occlusal portion with a rectangular-bladed off-angle Cavitip. Arrows indicate the rotation necessary to produce an occlusal dovetail.

Fig. 14.—The completed occlusal portion is extended through two-thirds of the marginal ridge and widened to self-cleansing areas.

Fig. 15.—The rectangular Cavitip is thrust to the proper gingival depth.

Fig. 16.—Arrows indicate the direction of buccal and lingual extensions to form a proximal slot.

Fig. 17.—Producing the proximal divergence for an amalgam preparation.

Fig. 18.—Producing the proximal divergence for an inlay preparation.

Fig. 19.—Use of the off-angle cylindrical Cavitip for the occlusal portion of a Class II preparation.

Fig. 20.—The same cylindrical Cavitip is thrust to the proper gingival depth.

Fig. 21.—Extension to produce the proximal divergence for an amalgam preparation.

Fig. 22.—Extension to produce the proximal divergence for an inlay preparation.

Fig. 23.—The initial thrust of the cylindrical Cavitip and the direction for planing to complete the triangular Class II form.

Fig. 24.—The nib surface of the inverted cone Cavitip is used to plane the lingual and gingival enamel in the direction parallel to the enamel rods.

The off-angle cylinders are similar in size to the No. 557 and No. 558 fissure burs. They cut rapidly in all directions and will do all of the operations that burs will do. In addition, they readily penetrate enamel. All classes of preparations may be made with these Cavitips if rounded vertical line angles are acceptable.

The rectangular flat-bladed Cavitip, which is slightly more limited than the cylinder, may be used also to complete many preparations.

SUMMARY

In the short span of three years, the ultrasonic dental instrument has been extensively investigated. Today, it is an instrument advantageous to the patient and dentist. Fortunately, all new developments were made in the expendable Cavitips and the power unit and handpiece remained the same. It is conceivable that additional improvements will follow.

Cavity preparation by the ultrasonic method is efficient in relation to the time required, and it is effective in making classical cavity preparations.

The greatest advantage of the ultrasonic unit is to the patient. Cavity preparation by this method is practically noiseless, vibrationless, heatless, and is well tolerated without local anesthesia.

REFERENCES

1. Oman, Carl R., and Applebaum, Edmund: Ultrasonic Cavity Preparation, Preliminary Report, New York State D. J. **20**:256-260, 1954.
2. Oman, Carl R., and Applebaum, Edmund: Ultrasonic Cavity Preparation. II. Progress Report, J.A.D.A. **50**:414-417, 1955.
3. Zach, Leo, and Brown, Gregory N.: Pulpal Effect of Ultrasonic Cavity Preparation. Preliminary Report, New York State D. J. **22**:9-17, 1956.
4. Lefkowitz, W., Robinson, H. B. G., and Postle, H. H.: Pulp Response to Cavity Preparation, J. Pros. Den., to be published.
5. Butt, Byron G., Harris, Norman O., Shannon, Ira L., and Zander, Helmut A.: Histopathological Evaluation of Pulpal Response to Ultrasonic Cavity Preparation, I.A.D.R. Preprinted Abstracts No. 34, March, 1956.
6. Zach, Leo: Thermogenetic Effect of Ultrasonic Cavity Preparation, I.A.D.R. Preprinted Abstracts No. 104, March, 1956.
7. Friedman, Joel, Lite, Theodore, and Solomon, Harold: Pulp Reactions to Ultrasonic Tooth Preparation, New York J. Den. **26**:144-148, 1956.
8. Healey, Harry J., Patterson, Samuel S., and Van Huysen, Grant: Pulp Reaction to Ultrasonic Cavity Preparation, Preliminary Report, U. S. Armed Forces M. J. **7**:685-692, 1956.
9. Zach, Leo, Morrison, A. H., and Cohen, Gerson: Thermogenetic Effects of Ultrasonic Cavity Preparation, N. Y. State D. J. **23**:123-127, 1957.
10. Robinson, Hamilton B. G.: Pulpal Effects of Operative Dentistry, J. Pros. Den. **7**:282-283, 1957.
11. Zach, Leo, Morrison, Arthur H., and Cohen, Gerson: Effects of Ultrasonic Operative Procedures on the Developing Dentition, I.A.D.R. Preprinted Abstracts No. 185, March, 1957.
12. Hartley, Jack L.: Cavity Preparation by Ultrasonic Versus Rotary Instrumentation, U. S. Armed Forces M. J. **8**:519-527, 1957.
13. Lefkowitz, W., Robinson, H. B. G., and Postle, H. H.: Clinical Survey of Ultrasonics in Restorative Dentistry, Part I and II, D. Survey **33**:1301-1305; 1465-1469, 1957.
14. Postle, H. H., and Lefkowitz, W.: The Present Status of Airbrasive and Ultrasonic Equipment, D. Clin. North America, p. 43-63, 1957.
15. Wilhelmy, Glenn E.: A Critical Evaluation of Ultrasonics in Operative Dentistry, D. Digest **63**:106-111, 134, 1957.

The Ohio State University
College of Dentistry
Columbus 10, Ohio

THE USE OF ULTRASONICS IN PERIODONTAL TREATMENT

JOHN R. WILSON, D.D.S.*
The Ohio State University, College of Dentistry, Columbus, Ohio

THE DISCUSSION IN THIS article will be limited to the possible use of ultrasonics in the field of periodontics.

Because of the newness of the use of ultrasonic devices in dentistry, and the even more recent use of this equipment as applied to periodontics, literature relating it to the practice of periodontics is extremely meager.

Zinner[1] included the application of the ultrasonic instrument to removal of calculus in his studies. He "planed off" calculus from teeth with water alone, instead of using a slurry. Necrotic cementum was also removed by this procedure. His report indicated that there was very little bleeding encountered in the subgingival procedures. He also indicated a lower degree of root sensitivity as compared to standard scaling techniques. His patients showed no adverse clinical symptoms.

Roth[2] reported a lack of gingival injury during use of the ultrasonic instruments. He concluded that this was a significant contribution to the practice of dentistry.

Valldaura[3] reported favorable bacteriostatic properties when ultrasonic irradiation was used in combination with antibiotic treatment. The report indicated general, as well as local, improvement when this method of treatment of periodontal disease was used.

In an unpublished Master's thesis, Leonard[4] reported the use of scaling tips adapted to ultrasonic application. Water alone was used in conjunction with the scaling procedures. It was noted that all calculus was removed from the teeth that were scaled. File tips that were adapted to this use produced apparent grooving and scratching of the enamel. Less bleeding of the gingival tissue was noted when the ultrasonically adapted tips were used than when conventional hand scalers were used.

Johnson and Wilson[5] have made a study covering both in vitro and in vivo application of the ultrasonic unit to scaling procedures. They designed seven scaling tips with which all surfaces of all the teeth could be reached. Scaling procedures were accomplished in the same mouth using conventional scalers on some teeth and the specially devised ultrasonic tips on other teeth. The teeth scaled by these two methods were then extracted to provide an investigative

Read before the Symposium on Ultrasonic Dentistry, Miami Beach, Fla., Nov. 3, 1957.
Received for publication Oct. 16, 1957.
*Chairman, Department of Periodontics.

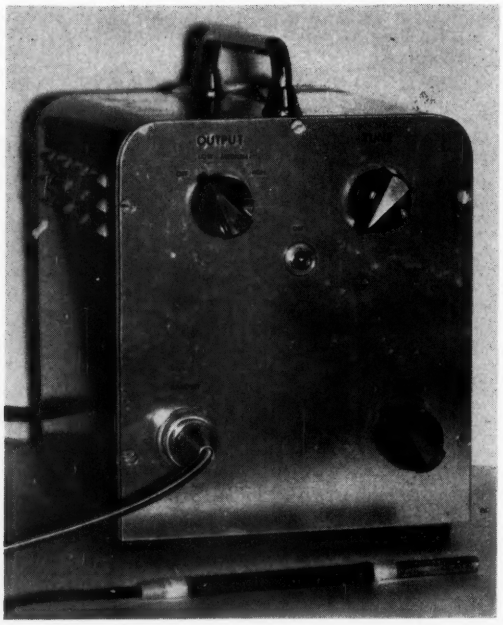


Fig. 1.—The ultrasonic instrument.

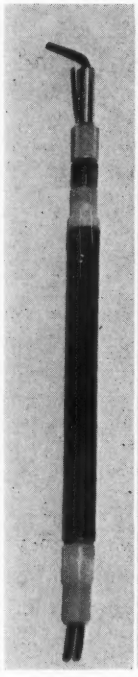


Fig. 2.

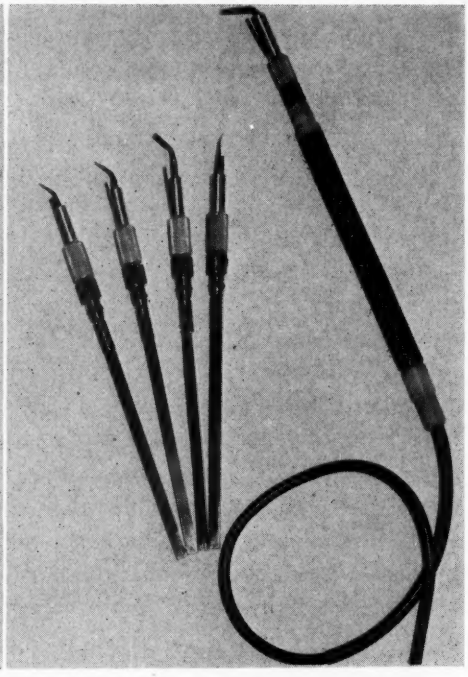


Fig. 3.

Fig. 2.—An ultrasonic handpiece.
Fig. 3.—The handpiece and inserts.

comparison. A qualitative comparison was made and a time study was accomplished also. They report the adequate removal of calculus more rapidly with the ultrasonic tips than with conventional scaling methods. They also state that cementum under the calculus is virtually unharmed.

The most recent development in the ultrasonic field relating to periodontal therapy has been the production of an ultrasonic unit* designed primarily for use in scaling procedures (Fig. 1).

Fig. 4. Fig. 5.

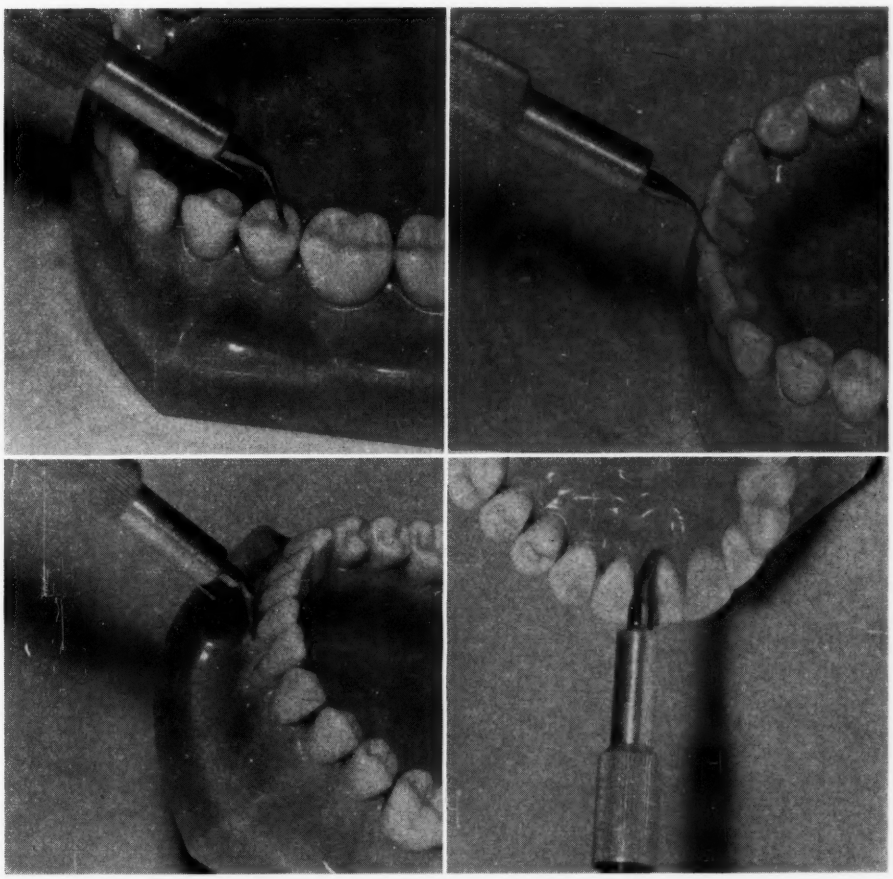


Fig. 6. Fig. 7.

Fig. 4.—Tip A is used for small crevices and fossae.
Fig. 5.—Tip A is used interproximally.
Fig. 6.—Tip B is used on the labial surfaces of lower anterior teeth.
Fig. 7.—Tip B is used on the lingual surfaces of upper anterior teeth.

The new instrument is much smaller than the one originally designed for making cavity preparations. Important improvements noted in the new instrument are:

1. A water temperature regulator built into the machine.

*Cavitron.

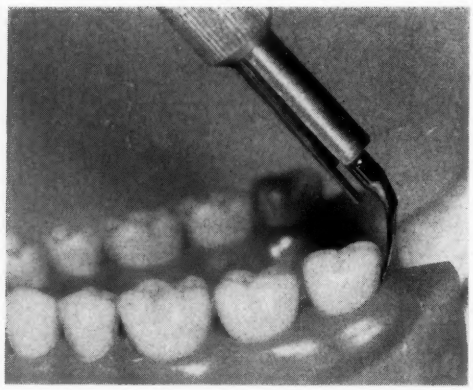


Fig. 8.—Tip B is used on the distal surfaces of molars.

Fig. 9. Fig. 10.

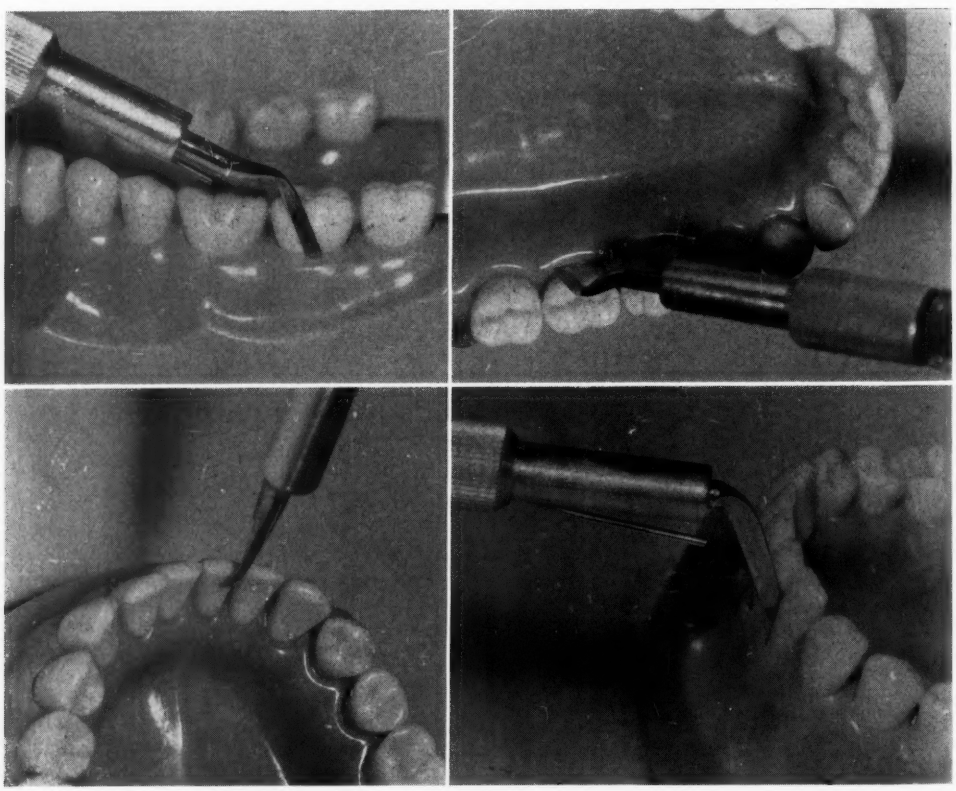


Fig. 11. Fig. 12.

Fig. 9.—Tip C is used on the buccal surfaces of molars.
Fig. 10.—Tip C is used on the lingual surfaces of molars.
Fig. 11.—Tip D is used on the lingual surfaces of lower anterior teeth.
Fig. 12.—Tip E is used on the interproximal surfaces.

2. A newly designed handpiece which is much lighter than others and which will allow the dentist a much better "feel" of root surfaces (Fig. 2).

3. An insert of new design which directs the flow of water more efficiently than the original handpiece. The new insert is advantageous in that the tip is a permanent part of the insert and can be changed quickly by simply removing the entire insert from the handpiece and replacing it with another insert to which is attached a different tip (Fig. 3).

Five tips have been designed for use in scaling procedures. The various tips which are now in experimental use, and the areas for which they were designed, are shown in Figs. 4 through 12.

Since this ultrasonic instrument has been in use but a short time, only its clinically observable use can be reported at this time.

The new unit appears to be very efficient for removing hard deposits. It is possible to use the instrument to remove thin stains on the crowns of teeth, but it seems to be inefficient in this regard, except in certain areas such as in crevices with very small dimensions where the energy released by cavitation apparently removes the stain. In accord with Crawford's findings,[6] only slight contact was necessary to remove the hard deposits, and increasing the pressure merely dampened the vibration and reduced the effectiveness. The water temperature control on the new instrument has proved to eliminate the previous difficulty encountered by Johnson and Wilson.[5]

No macroscopic gouging of the surface has been evidenced with the tips presently in use.

Some difficulty is encountered when indirect vision is attempted, since the use of water is essential. Scaling can be done with more ease if direct vision is used.

The patient reaction to the use of the ultrasonic instrument for scaling has been favorable. This was noted especially in patients where heavy deposits were to be removed and in patients with necrotizing ulcerative gingivitis where the tissue is extremely sensitive. Both conventional and ultrasonic methods were used in the same mouths, and patients have expressed a preference for the ultrasonic method. Patients have also expressed the feeling that their teeth felt smoother to the touch of the tongue when the ultrasonic unit was used than when conventional procedures were used.

This dental instrument is probably best suited for the removal of subgingival and supragingival gross calculus. Therefore, it is an effective adjunct to the equipment used by the dentist for the scaling procedures. As an instrument for removing thin stain on the crowns of the teeth, it is not nearly as effective as the rubber cup, brush, or Porte polisher. In its present state of development, it is probably not the complete answer to the problems of calculus removal, but it can be used to relieve much of the burden of removing heavy calculus, thus saving valuable time for other procedures.

Its versatility and effectiveness are now undergoing complete studies, and it is hoped that much more valuable information will soon be available in addition to these opinions which are based mainly on clinical research.

REFERENCES

1. Zinner, Doran, D.: Ultrasonic Studies in Dentistry: American Institute of Ultrasonics in Medicine; Proceedings of the Fourth Annual Conference on Ultrasonic Therapy, Library of Congress Number 55-12257, Aug. 27, 1955, pp. 6-16.
2. Roth, Lester H.: Application of the Ultrasonic Dental Handpiece, Preliminary Report, W. Virginia D. J. **30**:9, 1956.
3. Valldaura, A.: Ultrasonics in Dentistry, D. Abs. **1**:207, 1956. (From Zahnärztl. Rundschau **64**:602, 1955.)
4. Leonard, Wilmore B.: The Effect of Various Scaling Instruments on Tooth Root Surfaces, Unpublished Master's Thesis, The Ohio State University, 1956.
5. Johnson, Walter N., and Wilson, John R.: The Application of the Ultrasonic Dental Unit to Scaling Procedures, J. Periodont. **28**:264, 1957.
6. Crawford, Alan E.: Ultrasonic Engineering, London, 1955, Butterworths Scientific Publications, p. 246.

THE OHIO STATE UNIVERSITY
COLLEGE OF DENTISTRY
COLUMBUS 10, OHIO

ULTRASONIC TECHNIQUES FOR CROWN AND BRIDGE RETAINERS

STANLEY D. TYLMAN, D.D.S., M.S.*
University of Illinois, College of Dentistry, Chicago, Ill.

SINCE I FIRST LEARNED OF the ultrasonic technique several years ago, I have been interested in seeing if it were possible to prepare teeth for crown and bridge retainers by this method. At that time, it was my privilege to spend a day with Dr. Carl Oman, in his department at Columbia University, to see him work with the newly developed Cavitron equipment. I had the opportunity to work on extracted teeth and to observe his technique for preparing cavities on experimental animals and on patients. Based upon what I saw and upon my limited personal experience at that time, I felt that although the instrument and technique were somewhat limited (due to the lack of correct cutting-tip design and some shortcomings in the equipment), there was sufficient merit in the technique to warrant further investigation and experimentation with it. We have had the opportunity, during the past three years, of working with the ultrasonic technique at the University of Illinois and focusing our interest on the extracoronal types of preparations.

The technique and the equipment have been greatly improved since I first saw them several years ago. Also, after the first enthusiastic reception of the technique, the profession is now realizing that there are limitations and disadvantages which must be recognized along with the advantages.

Interest in this new technique has been both in the mechanical possibilities of its use and in its biologic aspects. Reports of biologic investigations have been published but there is still some question as to the reactions of the vital tissues to the use of ultrasonics. It is important to know if injury to tissues follows its use.

My interest in the method deals with its use for preparing teeth for complete crowns and for three-quarter partial veneer bridge retainers. It should be determined whether instruments and methods can be developed which might enable the average dentist to make good preparations for porcelain jacket and complete gold crowns. Also, it should be determined if preparations can be made on teeth for anterior or posterior three-quarter crowns which would be equal in mechanical retention and would have improved surface walls compared to teeth prepared by the standard rotating instruments. I am extremely interested to know the reactions of the pulp, periodontal membrane, and the contiguous bony structures to the ultrasonic vibrations used in making these preparations, as well as the relative amount of time required to make preparations by this method as compared to that required when rotating instruments are used.

Read before the Symposium on Ultrasonic Dentistry, Miami Beach, Fla., Nov. 3, 1957.
Received for publication Nov. 7, 1957.
*Professor of Dentistry, Head of the Crown and Bridge Department.

In an attempt to find the answers to these questions, this committee* undertook to survey the opinions of men who have used ultrasonics for the preparation of teeth for complete and three-quarter crowns.

From the reports,† it was evident that only a small percentage of complete crowns and three-quarter retainers were prepared entirely with ultrasonic instruments. In fact, one report indicated that out of 121,000 preparations, only 2,368 extracoronal and complete crowns were made in this manner. Another report indicated that at least 34 per cent of all types of preparations made with the ultrasonic technique were supplemented with hand or rotary instruments. It is apparent that either the cutting tips were not of the proper design at the time or the capacity of the instrument for removing tooth structure effectively was not sufficient. Since then, new shapes of Cavitips have been developed, and improvements have been made in the machine. The improvements in the design of the cutting tips have made possible a more extensive use of this method in making crown and bridge preparations. These improvements have reduced the length of time required for making such preparations. However, it must be recognized that the increased experience gained with any new technique would tend to result in better preparations made more quickly. It is necessary to understand and to follow three basic rules for good results with the ultrasonic technique.

Kohn stated in his report:† "There are three factors which are responsible for good cutting. The first is correct electrical power to the handpiece. This is obtained by the proper, careful handling of the Tune and Output dials on the control panel. Since this has not presented too much of a problem to the average Cavitron user, it is not necessary to go into this, other than to emphasize its importance as a link in the complete chain of cutting efficiency.

"The second is correct vibration as a result of efficient transmission of the electrical energy into mechanical energy. And this is based upon the maintenance of clean threads on both the handpiece end and the Cavitip end and also maintaining a perfect seat on the face of the threaded end of the handpiece. If this seat between Cavitip and handpiece is perfect, the two parts act as a single unit in its vibration, whereas the presence of water, dirt, or abrasive between the Cavitip and handpiece causes the two parts to vibrate as individual or separate units with a decided loss in cutting efficiency.

"The third factor in good cutting is the correct abrasive supply. This depends upon the proper amount of abrasive in the system, plus the proper application of this solution to the Cavitip because of the tip's vibration pattern."

SUMMARY

Replies to questionnaires about the preparation of teeth for porcelain jacket crowns, complete gold crowns, and for three-quarter partial veneer crowns indicate that dentists employing the ultrasonic technique are limiting themselves to the use of a very few Cavitips. These are usually the newer offset No. 15 and No. 331,

*The Committee for the Study of Ultrasonics in Dentistry.

†Reports given at Seminars held at the University of Illinois and The Ohio State University.

in addition to two or three of the older numbers. The techniques used vary in different parts of the country according to the individual experience. No single step-by-step procedure has been agreed upon as yet. That progress has been made in this direction is indicated by the fact that the operating time compares favorably now with that where rotary instruments are employed. Further study and research into this new method of tooth preparation is needed and should evolve the most efficient techniques for its use.

University of Illinois
College of Dentistry
808 South Wood St.
Chicago, Ill.

COMPARATIVE EVALUATION OF NEWER DEVICES AND TECHNIQUES FOR THE REMOVAL OF TOOTH STRUCTURE

JACK L. HARTLEY, MAJOR, USAF (DC)*
Randolph Air Force Base, Texas

CAVITY PREPARATION IN RESTORATIVE dentistry has been so well developed theoretically, and such high standards have been set for its practical execution, that it might be said to be physiologically perfect. Until recently, however, the instruments available for these procedures could not cope adequately with the harder substances of the tooth. In many instances, the desired results could not be obtained, even with the greatest skill.

The perfecting of newer devices and techniques for removing tooth structure has been the result of research designed to help the operator accomplish the preparation with a maximum of effectiveness and a minimum of objectionable sequelae. Evaluation of these instruments by the United States Air Force Dental Service at the National Bureau of Standards[1-4] and at the School of Aviation Medicine[5-6] is continuing.

In the present study, the clinical effectiveness of the newer instruments (high-speed, superspeed, and ultrasonic) was compared with that of the conventional low-speed instruments in widespread use in both civilian and military dentistry. Advantages of the newer handpieces have been described, but confusion continues to exist because of the variety of techniques. On the basis of a long period of satisfactory accomplishment, many dentists continue to use the time-tested, low rotational speeds. There is no doubt that although these methods may be satisfactory to the dentist, they are not comfortable to the patient. This study, therefore, includes patient response in the over-all concept of clinical effectiveness. Increase in cutting effectiveness, ease of operation, better control, and reduction of pressure and heat cannot be considered advantageous if it is accomplished at the expense of patient comfort.

The factors considered in this evaluation were: (1) cutting time; (2) over-all time of operation; (3) vibrations transmitted to the skull during cutting; and (4) patient response and the determination of an "annoyance factor" for each type of instrument.

The instruments employed in this investigation were:

(1) a standard handpiece and dental engine with conventional steel and carbide burs (rotational speed at the bur was 4,500 to 6,000 r.p.m.); (2) a high-

Read before the Symposium on Ultrasonic Dentistry, Miami Beach, Fla. Nov. 3, 1957.

The opinions or assertions contained herein are those of the author and are not to be construed as official or as reflecting the view of the Department of the Air Force or the Air Service at large.

Received for publication Nov. 1, 1957.

*Head, Restorative Dentistry Section, Research Dentistry Division, Air University, School of Aviation Medicine.

speed handpiece powered by a conventional dental engine which had been prepared to deliver speeds at the bur of 12,000 to 16,000 r.p.m. with carbide burs and diamond points; (3) a hydraulically rotated handpiece, employing diamond points (speed measured at the diamond instrument was 45,000 r.p.m.); (4) a superspeed handpiece which obtained the speed increase by means of miniature pulleys and a belt within the sheath (The conventional dental unit was altered by removal of the high-speed resistance shunt and the use of a large diameter pulley upon the motor. Rotational speeds were from 80,000 to 120,000 r.p.m. The cutting instruments were carbide burs); and (5) a comparatively recent development which utilizes ultrasonic vibration to produce cutting with an abrasive slurry of aluminum oxide. The frequency was 29,000 cycles per second.[5]

All handpieces are commercially available. A coolant spray of water or water and air was used with all procedures.

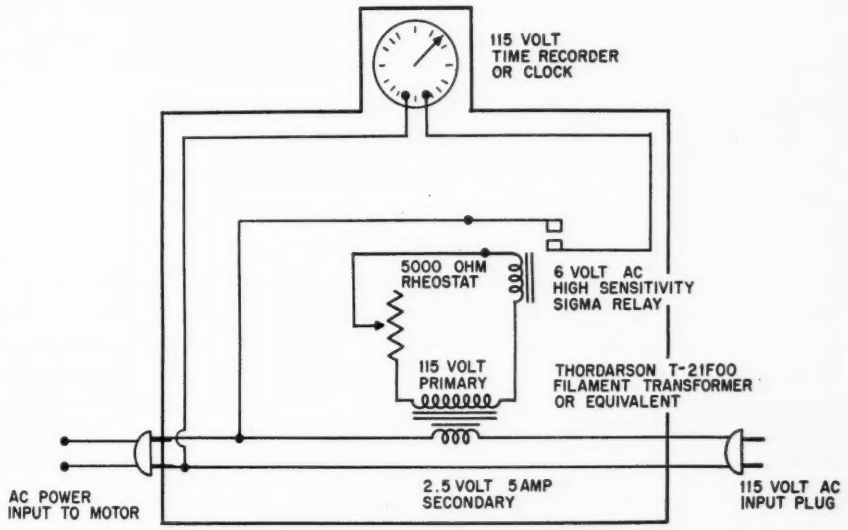


Fig. 1.—A schematic diagram of the timer mechanism employed in the determination of cutting time. This clock was activated by the foot control of the dental unit.

METHODS

Cutting Time.—Cutting time was established, for the purpose of this evaluation, to be the actual duration of flow of energy to the handpiece during mechanical removal of tooth structure. When the foot control of the engine was activated, an interval timer was automatically started; release of the foot control stopped the timer (Fig. 1). The total time of cutting was thus recorded.

The Over-all Time of Operation.—This was measured by an electric self-starting clock, activated manually by the assistant upon commencement of the operation. The time included administration of anesthetic if employed and ended with the completion of the preparation. Hand instrumentation was, therefore, also timed.

Vibrations Transmitted to the Skull During Cutting.—Much of the discomfort in a dental procedure involving removal of hard tooth structure is caused by the annoying and often painful vibrations transmitted through the bones of the head to the hearing mechanism. This is a frequent complaint of patients, and even though they may be anesthetized, these vibrations continue to be a major cause for dreading dental procedures. To evaluate, objectively, the noise produced by the various cutting methods, tape recordings were made of vibrations transmitted to the skull during the dental procedure. A bone conduction microphone was applied to the frontal bone and held by an elastic bandage. The recorder gain control was set at the same point for all determinations in order to permit comparison of the amplitude of vibration transmitted to the skull by each instrument. The tapes produced could be replayed whenever necessary. Connection of the tape playback output to an oscilloscope permitted analysis of the vibration wave patterns for frequency and amplitude determinations.

Patient Response and the Determination of an Annoyance Factor for Each Type of Instrument.—After each cavity was prepared, the patient was asked to comment on the degree of discomfort experienced. This information was correlated with the recorded vibrations of that particular handpiece to produce a tentative annoyance factor for each type of instrument and technique studied.

PROCEDURE

All operative procedures were accomplished by the same dentist. Data were recorded on all usual types of cavity preparations; a minimum of ten operations by each handpiece technique for each type of cavity preparation was required for statistical significance. Delineating the size of the cavities by recording the above data separately for anteriors, bicuspids, and molars gave greater significance to the study. Whenever possible, all five handpieces were used on the same patient.

The patients were told that a new device for the removal of tooth structure was to be employed. They were asked to permit initial cutting without a local anesthetic but were to request an anesthetic immediately upon perception of any more than the slightest pain. They were assured that it was not necessary for them to bear any degree of pain. The use or elimination of an anesthetic was recorded in all procedures. While no technique evaluated was painless, many were completely tolerated, the patient preferring to proceed without an anesthetic.

RESULTS

Low Speed.—Cavity preparation with conventional low speed (4,500 - 6,000 r.p.m.) required the longest cutting time; the over-all time of operation was greater than with any other method, and an anesthetic was required in all cases (Table I).

This procedure was most bothersome to the patient. Many expressed a dislike for the pressure required to cut, and the fear that the dentist "might slip and go right through my cheek." In many cases, these remarks were made by patients who had previously been exposed to one or more of the newer handpieces. In every case, patients preferred any of the newer devices to conventional low-speed cutting.

TABLE I. THE CUTTING TIME AND OVER-ALL TIME OF PREPARATION OF COMMON TYPES OF DENTAL RESTORATIONS BY A CONVENTIONAL HANDPIECE ROTATING AT 4,500 TO 6,000 R.P.M.

(Average for 10 Preparations of Each Type)

TOOTH	CLASS I		CLASS II		CLASS III		CLASS V		¾ CROWN		FULL CROWN	
	TIME		TIME		TIME		TIME		TIME		TIME	
	A	B	A	B	A	B	A	B	A	B	A	B
Anterior					3.8	13.0	2.8	12.0	12.0	30.0	17.0	36.0
Bicuspid	2.5	8.0	4.9	15.0			2.1	9.0	14.0	33.0	18.0	35.0
Molar	2.5	10.0	4.9	15.0			3.5	12.0	15.0	35.0	19.0	35.0

Time A: Cutting time with handpiece.
Time B: Over-all preparation time.

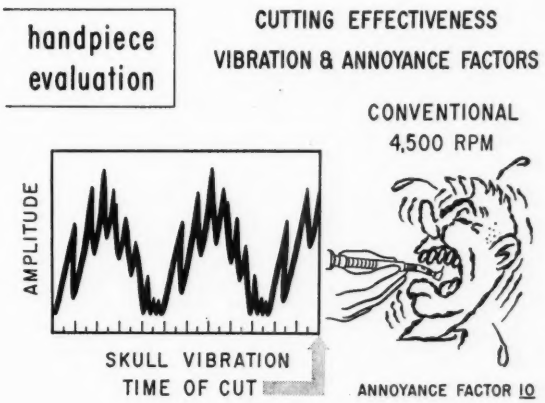


Fig. 2.—The relative amplitude and frequency of vibrations recorded from the skull of the patient during cutting with a conventional handpiece at 4,500 r.p.m. The relative time of preparation of an average restoration is indicated. The annoyance factor of 10 is represented in the caricature.

Cutting time averaged 3.4 minutes for all intracoronal preparations by the low-speed handpiece. The average time for profound anesthesia, including administration, was 5 minutes; over-all time of operation, which included all procedures necessary for cavity preparation by rotational cutting at 4,500-6,000 r.p.m., was 11.7 minutes. The over-all time of operation for all extracoronal preparations was 34 minutes.

The relative amplitude of vibrations transmitted to the skull during 4,500 to 6,000 r.p.m. cutting was the highest of all recordings in this experiment at the constant setting of the tape recorder gain control. An "annoyance factor" number of 10 was assigned to this level on the basis of the adverse response of patients (Fig. 2).

High Speed.—Removal of tooth structure by high-speed cutting at 12,000 to 16,000 r.p.m. was more rapid than by the low-speed technique; average cutting time was 2.3 minutes. Over-all time of operation was reduced considerably, since an anesthetic was required in only 50 per cent of the preparations. Over-all intracoronal preparation time was 4.8 minutes. Over-all time of preparation of extracoronal restorations was 16.5 minutes (Table II). All patients preferred

TABLE II. THE CUTTING TIME AND OVER-ALL TIME OF PREPARATION BY THE HIGH-SPEED HANDPIECE ROTATING AT 12,000 TO 16,000 R.P.M.

(Average for 10 Preparations of Each Type)

TOOTH	CLASS I		CLASS II		CLASS III		CLASS V		¾ CROWN		FULL CROWN	
	TIME		TIME		TIME		TIME		TIME		TIME	
	A	B	A	B	A	B	A	B	A	B	A	B
Anterior					2.9	3.8	2.0	4.0	8.0	17.0	7.0	15.0
Bicuspid	1.6	3.0	2.8	6.0			1.8	3.0	12.9	20.0	15.0	19.0
Molar	1.8	3.5	3.5	6.0			1.8	3.8	13.0	20.0	15.0	20.0

Time A: Cutting time with handpiece.
Time B: Over-all preparation time.

this handpiece to the low-speed instrument. Some patients commented on the "feel" of this handpiece and expressed the opinion that it seemed to be free of many of the annoying vibrations peculiar to the low-speed handpiece while cutting. Diamond instruments and carbide burs were employed with this handpiece. Pressures required to cut adequately were higher than those pressures necessary to prevent loss of diamonds. Under the higher pressures, the diamond instruments rapidly lost their effectiveness, and, thus, the time of cutting was increased.[3] Car-

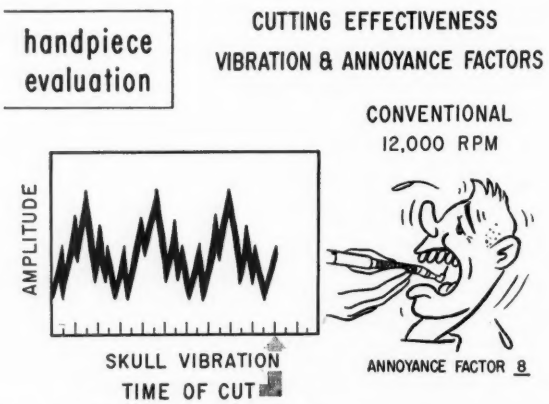


Fig. 3.—The relative amplitude and frequency of vibrations recorded from the skull of the patient during cutting with a high-speed handpiece rotating at 12,000 r.p.m. The relative time of preparation of an average restoration is also indicated. The annoyance factor of 8 is represented in the caricature.

bide burs removed soft tooth structure very effectively, but their action in enamel was noisy and time consuming.[2] An annoyance factor of 8 was tentatively assigned (Fig. 3).

Hydraulic Turbine.—Removal of tooth structure by the hydraulically driven handpiece at 45,000 r.p.m. reduced the average cutting time to 2.0 minutes. The over-all time of operation was reduced to 3.2 minutes (average), and the average over-all time for extracoronal preparations was 12.3 minutes (Table III). Local anesthetic was not required.

TABLE III. THE CUTTING TIME AND OVER-ALL TIME OF PREPARATION BY THE HYDRAULIC TURBINE HANDPIECE ROTATING AT 45,000 R.P.M.
(Average for 10 Preparations of Each Type)

TOOTH	CLASS I		CLASS II		CLASS III		CLASS V		¾ CROWN		FULL CROWN	
	TIME		TIME		TIME		TIME		TIME		TIME	
	A	B	A	B	A	B	A	B	A	B	A	B
Anterior					2.9	3.8	1.0	1.9	6.5	8.0	6.8	10.5
Bicuspid	1.9	3.0	2.8	4.8			1.5	2.0	8.0	11.0	9.5	14.2
Molar	1.5	3.0	2.6	5.5			1.5	1.8	10.5	14.9	12.8	15.0

Time A: Cutting time with handpiece.
Time B: Over-all preparation time.

Patient response was favorable to cutting by this instrument. Cutting was very rapid and required a minimum of pressure. Removal of enamel was accomplished by a very gentle wiping action. All preparations were accomplished with diamond and hand instruments only. This instrument was quiet in operation, a factor commented upon by patients and one which also must be considered. Although only bone-conducted vibrations were recorded by the microphone placed on the frontal bone, noise arising from the instrument as it is brought to the patient's mouth before contact is a definite factor in patient response. The plastic tube carrying water to and from the head of the handpiece was an interesting feature of this instrument. It offered virtually no hindrance to any manipulation necessary for cavity preparation and could be placed in any position without interfering with its operation or the comfort of the patient. Tape recordings of skull vibrations were analyzed and correlated with patient response resulting in an "annoyance factor" of 4 for this instrument (Fig. 4).

Superspeed.—Cutting with the superspeed handpiece, rotating at 80,000 to 120,000 r.p.m., was slightly more effective than with the 45,000 r.p.m. handpiece. Cutting time average was 1.7 minutes for intracoronal preparations. Over-all time of operation was 2.9 minutes. A local anesthetic was not requested by any of the patients. Average over-all time of extracoronal preparations was 12.3 minutes (Table IV). Failure to decrease cutting time to a greater extent was believed due to the fact that diamond instruments were not available when this handpiece was

TABLE IV. THE CUTTING TIME AND OVER-ALL TIME OF PREPARATION BY THE SUPERSPEED HANDPIECE ROTATING AT 80,000 TO 120,000 R.P.M.

(Average for 10 Preparations of Each Type)

TOOTH	CLASS I		CLASS II		CLASS III		CLASS V		¾ CROWN		FULL CROWN	
	TIME		TIME		TIME		TIME		TIME		TIME	
	A	B	A	B	A	B	A	B	A	B	A	B
Anterior					1.5	3.0	.9	1.5	6.5	9.0	5.0	10.0
Bicuspid	1.7	2.9	3.0	4.0			1.6	2.0	7.5	12.0	9.4	14.5
Molar	1.5	2.8	2.3	5.0			1.3	1.9	10.0	13.0	11.9	15.0

Time A: Cutting time with handpiece.
Time B: Over-all preparation time.

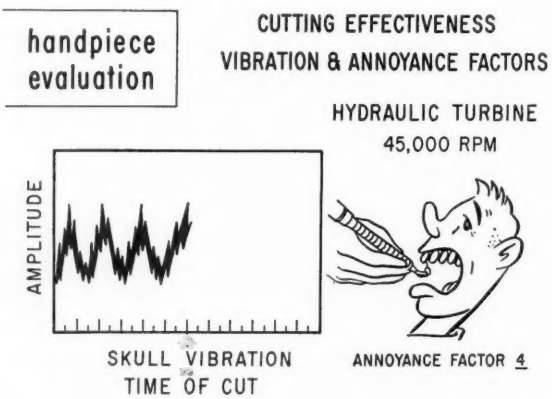


Fig. 4.—The relative amplitude and frequency of vibrations recorded from the skull of the patient during cutting with the hydraulic handpiece rotating at 45,000 r.p.m. The relative time of preparation of an average restoration is also represented. The annoyance factor of 4 is represented in the caricature.

purchased; therefore, cutting was limited to carbide burs. Diamond points can be assumed to be far more effective as rotational speeds are increased.[3] Handpiece noise, without contacting the tooth, was high. Three patients commented upon this. A typical comment was, "That thing would frighten a child or nervous individual." The frequency or pitch of the vibration produced by this instrument while cutting with a carbide bur was very annoying to the patient and the dentist. As with any of the superspeed handpieces, low-speed procedures such as finishing of margins, polishing, and the use of sandpaper disks required another handpiece. The removal of the superspeed handpiece from the arm and changing of belts and

pulley systems were very time-consuming. This is not a problem when the superspeed handpiece is a separate unit (such as the ultrasonic and hydraulic devices). The conventional instrument remains readily available for low-speed procedures. The recordings of skull vibrations were somewhat lower in intensity or amplitude than was expected considering the noise level which was apparent as the instrument operated outside the mouth before cutting. The frequency was high and of a pitch which was at times irritating to the patient. Use of diamond points with this instrument will be investigated; it is possible that the higher vibrational frequencies, then produced, would not irritate the patient. On the basis of patient response, an annoyance factor of 5 was assigned this instrument (Fig. 5). The instrument was light and well balanced; no more difficulty was encountered in manipulation of this instrument than with conventional handpieces.

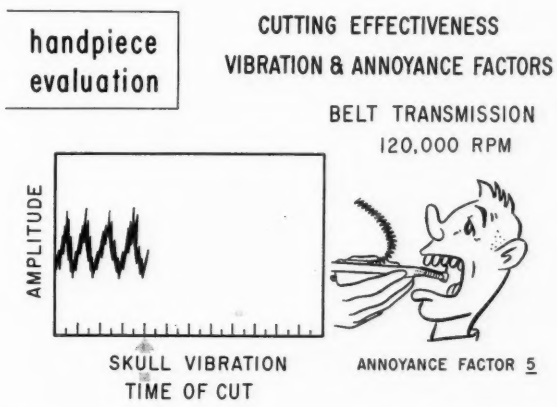


Fig. 5.—The relative amplitude and frequency of vibrations recorded from the skull of the patient during cutting with the superspeed handpiece at 120,000 r.p.m. The relative time of preparation of an average restoration is also indicated. The annoyance factor of 5 is represented in the caricature.

Ultrasonic.—Cutting tooth structure with the ultrasonic instrument was less effective than with the superspeed instruments but equal to cutting with the instruments rotating at 4,500 to 6,000 r.p.m. The average ultrasonic cutting time for all intracoronal preparations was 3.3 minutes. The average over-all time was 6.1 minutes for intracoronal preparation by the ultrasonic instrument. Extracoronal preparations required an average of 34.6 minutes; this was approximately the same as for the low-speed method. An anesthetic was not required; therefore, manipulation of the ultrasonic handpiece required more time than the other handpiece evaluated (Table V). Visibility was poor because of the accumulation of slurry on the tooth. This situation was aided somewhat by the use of a high-volume, low-suction, vacuum-cleaner type aspirator. Maximum visibility was obtained by frequent stops to permit the patient to rinse his mouth. Changing the cutting tips required more time than was required by the other instruments; the average time necessary to accomplish this was 30 seconds.

TABLE V. THE CUTTING TIME AND OVER-ALL TIME OF PREPARATION BY THE ULTRASONIC INSTRUMENT VIBRATING AT 29,000 C.P.S.

(Average for 10 Preparations of Each Type)

TOOTH	CLASS I		CLASS II		CLASS III		CLASS V		¾ CROWN		FULL CROWN	
	TIME		TIME		TIME		TIME		TIME		TIME	
	A	B	A	B	A	B	A	B	A	B	A	B
Anterior					3.9	8.0	2.3	6.2	11.0	20.0	15.0	30.0
Bicuspid	1.6	3.0	5.2	9.0			1.9	3.9	13.0	27.0	16.0	35.0
Molar	2.9	4.5	5.4	9.0			3.2	4.9	14.0	27.0	19.0	34.0

Time A: Cutting time with handpiece.
Time B: Over-all preparation time.

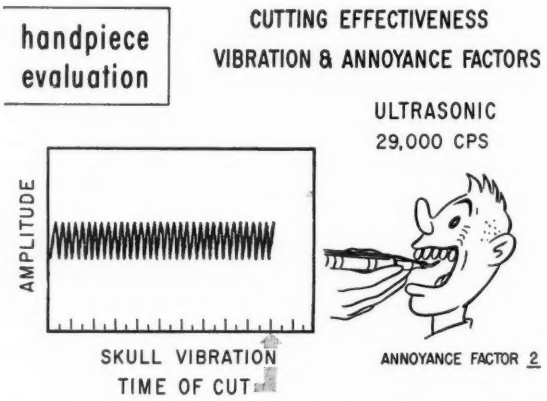


Fig. 6.—The relative amplitude and frequency of vibrations recorded from the skull of the patient during cutting with the ultrasonic instrument. The relative time of preparation of an average restoration is also indicated. The annoyance factor of 2 is represented in the caricature.

The patient response to ultrasonic cutting was the most favorable in this study. All had had cavity preparation by other methods prior to ultrasonic preparation. Some had permitted use of the low-, high-, and superspeed handpieces in subsequent cavity preparations for re-evaluation purposes. Again, the patients expressed the desire to return to the ultrasonic instrument. Vibration intensities as recorded on tape during cutting were the lowest of all methods evaluated. The frequency of vibrations at the cutting tip were 29,000 c.p.s. (above the audible range). However, cutting was audible to the patient. This was apparently due to the movement of the aluminum oxide particles against tooth structure as they cut. An annoyance factor of 2 was assigned to this instrument, thus establishing it as the least annoying handpiece evaluated in this study (Fig. 6).

DISCUSSION

It was not the purpose of this study to recommend or advise the use of any one advanced-design handpiece. Three points do become evident as a result of this evaluation. (1) The low-speed conventional instrument operating at 4,500 to 6,000 r.p.m. should not be considered in the modern concept of restorative dentistry. The cutting is not effective, pressures are excessive, the annoyance factor is high, and anesthetics are required. These factors undoubtedly contribute greatly to the common fear of a dental operative procedure. Cutting a deciduous tooth with this type of instrument gives the child a permanent distaste for dental procedures. (2) The reduced hand pressures and intensity of noise, greatly reduced time of contact of the instrument, and minimal traumatic vibrations produced by the newer devices and techniques make it possible for the patient to accept more actual dental work per chair hour. (3) The superior control possible with a handpiece which cuts effectively with the lightest of pressures permits closer adherence to the exacting details of proper cavity preparation. These procedures are accomplished with vastly reduced effort and fatigue.

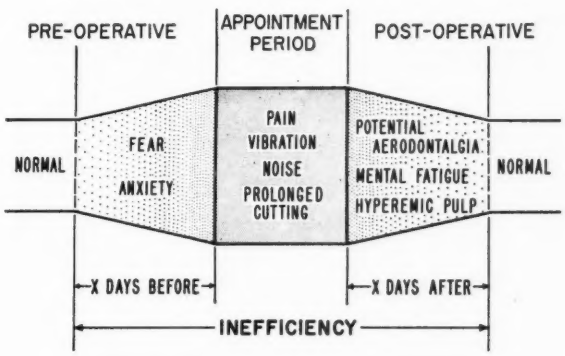


Fig. 7.—A graphic representation of the extended effectiveness concept. This chart illustrates the harmful effects of conventional low-speed dental cutting which extends for X number of days before and after a traumatic dental appointment.

SUMMARY

An over-all effectiveness concept can be resolved from this study. The term "effectiveness" could theoretically be extended to include a period of from an hour to several days prior to the actual appointment period. Another variable period occurs postoperatively. All dental practitioners are aware of the unique aura which occurs to patients prior to their appointment. This is brought about by fear, anticipation of pain, or memories of unpleasant episodes related to removal of tooth structure. After treatment, such occurrences as prolonged anesthesia with its coincidental side effects, pulpal hyperemia caused by excessive temperatures and pressures, neuromuscular fatigue, and nervous exhaustion are not uncommon (Fig. 7). Most of these factors are no longer present after the initial session of cavity preparation with one of the newer instruments. The effectiveness of these

handpieces then can be said to extend beyond the appointment period proper (Fig. 8). A patient who dreads a dental appointment during which tooth structure is to be removed in the conventional low-speed manner might conceivably perform his own duties with reduced efficiency because of this. There is little doubt that for a variable period after a traumatic dental session, the patient cannot work at optimum efficiency.

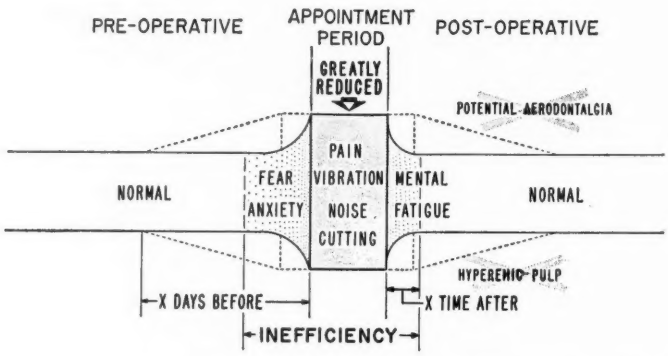


Fig. 8.—A graphic representation of the extended effectiveness concept. This chart illustrates the over-all benefits obtained by the removal of tooth structure with the newer devices and techniques evaluated in this experiment.

It is of interest to note that in the over-all time of operation the difference in high-speed and superspeed was not great (Table VI). The importance of "how fast" a dental procedure can be performed should be minimized. All preparations were accomplished by the same dentist during this experiment. These could have been prepared by another dentist in a longer or shorter time. This investigator did note, as paramount, the fact that with effective instrumentation there was more time available for attention to the minutest details in cavity preparation with no increase, but rather with an actual decrease in time.

CONCLUSIONS

1. Removal of tooth structure by conventional low-speed rotary cutting at 4,500 to 6,000 r.p.m. was less effective than with the other methods studied and most annoying to the patient. Local anesthetics were required in all cases accomplished under the conditions of this experiment. On the basis of intensity of vibrations transmitted to the skull during cutting and of patient response an annoyance factor of 10 was assigned to this method.

2. High-speed cutting at 12,000 to 16,000 r.p.m. was not as effective as with the superspeed devices but more effective than with the ultrasonic and conventional low-speed instruments. Vibrations during cutting with steel and carbide burs were of a high intensity. Cutting with diamond points produced vibrations of lower intensity and was less annoying to the patient. Anesthetics were required in 50 per cent of the preparations. An annoyance factor of 8 was assigned this method.

TABLE VI. A SUMMARY OF CUTTING TIMES AND OVER-ALL TIMES OF OPERATION BY THE FIVE METHODS EVALUATED IN THIS STUDY

(Average for 10 Preparations of Each Type)

TOOTH	CLASS I		CLASS II		CLASS III		CLASS V		¾ CROWN		FULL CROWN	
	TIME		TIME		TIME		TIME		TIME		TIME	
	A	B	A	B	A	B	A	B	A	B	A	B
Conventional					3.8	13.0	2.8	12.0	12.0	30.0	17.0	36.0
High-speed					2.9	3.8	2.0	4.0	8.0	17.0	7.0	15.0
Ultrasonic					3.9	8.0	2.3	6.2	11.0	20.0	15.0	30.0
Hydraulic					2.9	3.8	1.0	1.9	6.5	8.0	6.8	10.5
Superspeed					1.5	3.0	0.9	1.5	6.5	9.0	5.0	10.0
Anterior												
Conventional	2.5	8.0	4.9	15.0			2.1	9.0	14.0	33.0	18.0	35.0
High-speed	1.6	3.0	2.8	6.0			1.8	3.0	12.9	20.0	15.0	19.0
Ultrasonic	1.6	3.0	5.2	9.0			1.9	3.9	13.0	27.0	16.0	35.0
Hydraulic	1.9	3.0	2.8	4.8			1.5	2.0	8.0	11.0	9.5	14.2
Superspeed	1.7	2.9	3.0	4.0			1.6	2.0	7.5	12.0	9.4	14.5
Bicuspid												
Conventional	2.5	10.0	4.9	15.0			3.5	12.0	15.0	35.0	19.0	35.0
High-speed	1.8	3.5	3.5	6.0			1.8	3.8	13.0	20.0	15.0	20.0
Ultrasonic	2.9	4.5	5.4	9.0			3.2	4.9	14.0	27.0	19.0	34.0
Hydraulic	1.5	3.0	2.6	5.5			1.5	1.8	10.5	14.9	12.8	15.0
Superspeed	1.5	2.8	2.3	5.0			1.3	1.9	10.0	13.0	11.9	15.0
Molar												

Time A: Cutting time with handpiece.
Time B: Over-all preparation time.

3. Cutting at 45,000 r.p.m. with the hydraulic handpiece was very effective. All preparations were accomplished with diamond points which were less irritating than steel or carbide burs. Patient response to cutting with this instrument was very favorable. Anesthesia was not requested. The intensity of vibrations was greater than with the ultrasonic cutter but of a frequency which was not annoying to the patient. An annoyance factor of 4 was assigned this method.

4. Removal of tooth structure by cutting at 80,000 to 120,000 r.p.m. was the most effective under the conditions of this experiment. The frequency of vibrations transmitted to the skull was annoying to the patient; the amplitude was equal to those vibrations produced by the 45,000 r.p.m. instrument. An annoyance factor of 5 was assigned to this instrument.

5. Ultrasonic cutting time was equal to that of the conventional low-speed handpiece. The over-all time of preparation was less than with the 4,500 to 6,000 r.p.m. handpiece. Anesthetics were not requested by the patients. Vibrations recorded on tape from the skull were the lowest in intensity of all the methods evaluated. The frequency of those vibrations was not bothersome to the patient. An annoyance factor of 2 was assigned this method.

6. An extended effectiveness concept was resolved from these experiments. This was based upon the favorable reaction of patients to cutting with the newer instruments. These handpieces greatly reduce the trauma incidental to removal of hard tooth structure. In this manner the nervous anticipation preceding a dental appointment and the mental fatigue following are also reduced. This concept then extends the effectiveness of these instruments over a time period greater than the dental appointment and contributes much toward achieving the ideals of modern dentistry.

REFERENCES

1. Hudson, D. C., and Sweeney, W. T.: Temperatures Developed in Rotating Dental Cutting Instruments, J.A.D.A. **48**:127-133, 1954.
2. Hudson, D. C., Hartley, J. L., Moore, R., and Sweeney, W. T.: Factors Influencing the Cutting Characteristics of Rotating Dental Instruments, J.A.D.A. **50**:377-382, 1955.
3. Hartley, J. L., Hudson, D. C., Sweeney, W. T., and Dickson, G.: Methods for Evaluation of Rotating Diamond-abrasive Dental Instruments, J.A.D.A. **54**:637-644, 1957.
4. Hartley, J. L., Hudson, D. C., Sweeney, W. T., and Richardson, W. P.: Cutting Characteristics of Dental Burs as Shown by High-speed Photomicrography, U. S. Armed Forces M. J. **8**:209-218, 1957.
5. Hartley, J. L.: Cavity Preparation by Ultrasonic Versus Rotary Instrumentation. In Vitro Cutting Effectiveness and Heat Production, U. S. Armed Forces M. J. **8**: 519-527, 1957.
6. Butt, B., Harris, N. O., Shannon, I., and Zander, H.: Ultrasonic Removal of Tooth Structure. I. A Histopathologic Evaluation of Pulpal Response in Monkeys After Ultrasonic Cavity Preparation, J.A.D.A. **55**:32-36, 1957.

AIR UNIVERSITY
SCHOOL OF AVIATION MEDICINE, USAF
RANDOLPH AIR FORCE BASE, TEXAS

CONDENSATION OF AMALGAM WITH ULTRASONIC VIBRATION

EUGENE W. SKINNER, PH.D.,* AND GENA T. MIZERA**
Northwestern University, The Dental School, Chicago, Ill.

THE USE OF ULTRASONIC vibration for the preparation of alloys is being introduced into certain industrial procedures.[1] Treating of the alloy or metal with ultrasonic vibrations during solidification affects the crystallization and grain structure of the metal.

Since the dental amalgam is essentially a molten alloy during the hardening period, it was considered that an investigation of the condensation of dental amalgam while it is subjected to sound vibrations of supersonic frequency might be of value. The source of the ultrasonic energy was the dental unit manufactured by the Cavitron Equipment Corporation, known as the Cavitron, Model No. C200.

EQUIPMENT

The Cavitron consists of an ultrasonic generator by means of which ultrasonic energy is delivered to a dental handpiece. The frequency is given as 29,000 vibrations per second. The equipment is provided with an output control and a tuning dial. A certain output is selected, and the circuit is tuned to provide a resonance depending upon the characteristics of the handpiece and similar design factors. When such resonance is attained, a peak input energy is delivered to the condenser point.

As the setting of the output dial is increased, the amplitude of the vibration is enhanced at resonance. In the present study, output stages of the arbitrary dial settings between 50 and 90 were used. The energy delivered at settings below 50 appeared to be ineffective, and at settings above 90, the response of the instrument was erratic.

The instrument was tuned at each output setting by means of a dial micrometer arrangement. The handpiece was adjusted vertically with the condenser point in contact with a dial micrometer. The unit was then tuned so that the maximum deflection of the dial micrometer was observed. This setting was then employed for the condensation of the amalgam.

The water and abrasive tubes were disconnected from the equipment.

Read before the Symposium on Ultrasonic Dentistry, Miami Beach, Fla., Nov. 3, 1957.
Received for publication Oct. 18, 1957.
*Professor of Physics.
**Technician.

CONDENSERS

Four different condensers were employed with the ultrasonic unit (Fig. 1). The condensers are tabulated in Table I as shown from left to right in Fig. 1. A smaller Cavitip was supplied with the unit, but it was useless for amalgam condensation.

The special condenser was designed to produce linear vibrations only, whereas the vibrational motion of the contra-angled points would be mainly elliptical. As will be shown later, there was no observable difference in the amalgams condensed with the special point and point No. 33. Consequently, the two were used interchangeably in the later portions of the research.

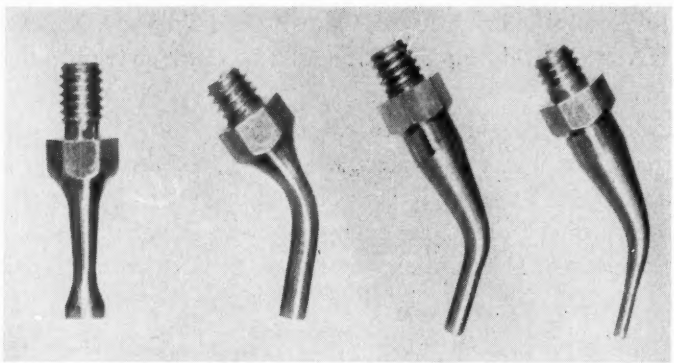


Fig. 1.—Four condenser points employed. From left to right: special, No. 33, No. 32, No. 31.

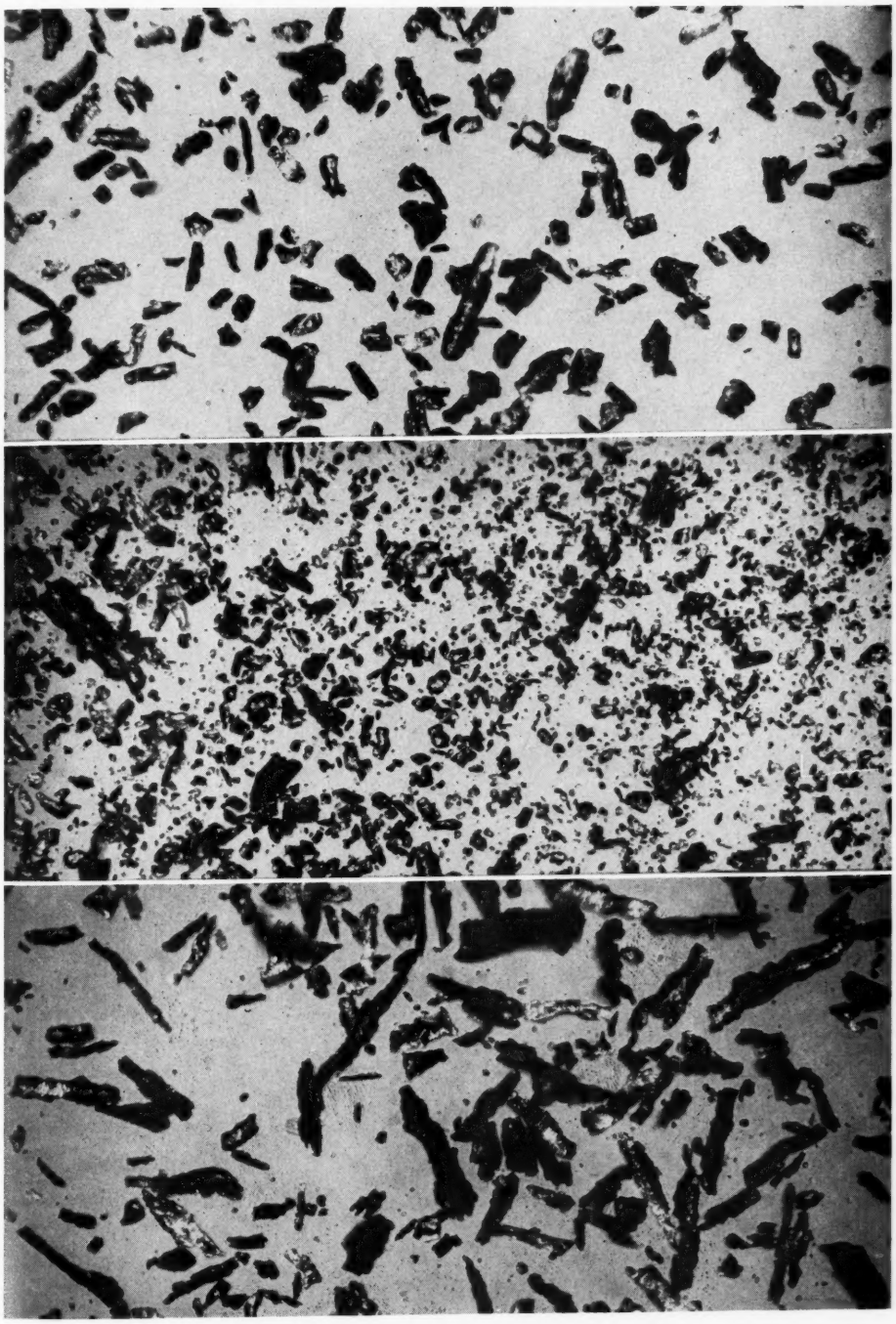
TABLE I. DIMENSIONS OF THE CONDENSER POINTS EMPLOYED

CONDENSER NO.	DIAMETER (MM.)	SURFACE AREA (MM.^{2})
Special*	3.0	7.1
33	2.0	3.1
32	1.5	1.8
31	1.0	0.8

*Straight shank; all other condensers were contra-angle.

AMALGAM ALLOYS

Seven different commercially available amalgam alloys were employed in the research. Photomicrographs of the particles of each alloy are shown in Figs. 2 to 8 inclusive. Each alloy was selected on the basis of certain characteristic variables which might influence the condensation. For example, alloys A, B, and C (Figs. 2 to 4) are characterized by differences in particle size. As far as is known, they do not differ radically in composition. Alloy D (Fig. 5) contains no copper, and alloy E contains no zinc (Fig. 6). Alloy F was supplied in pellet form (Fig. 7), as



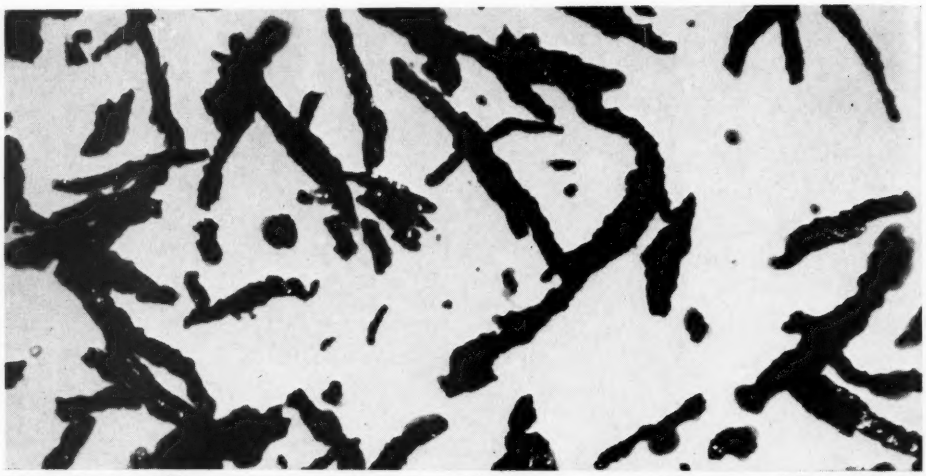
2.

3.

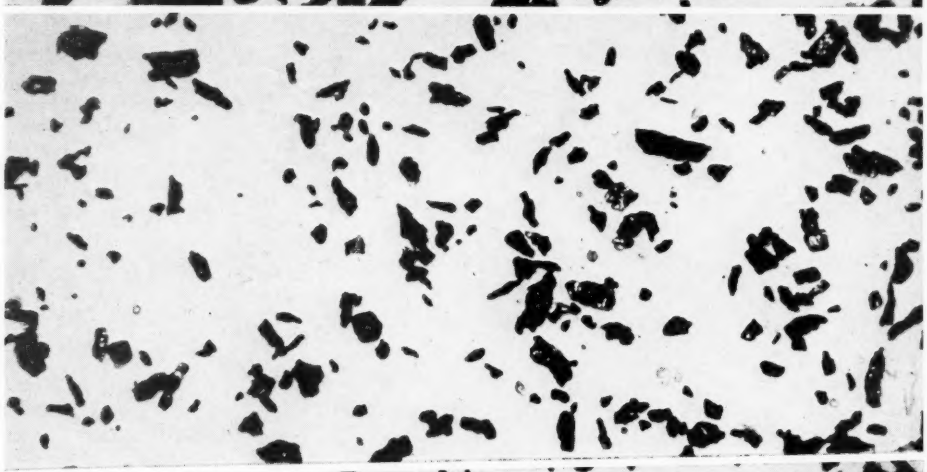
4.

Fig. 2.—Particles of alloy A. (x90.)
Fig. 3.—Particles of alloy B. (x90.)
Fig. 4.—Particles of alloy C. (x90.)

5.



6.



7.

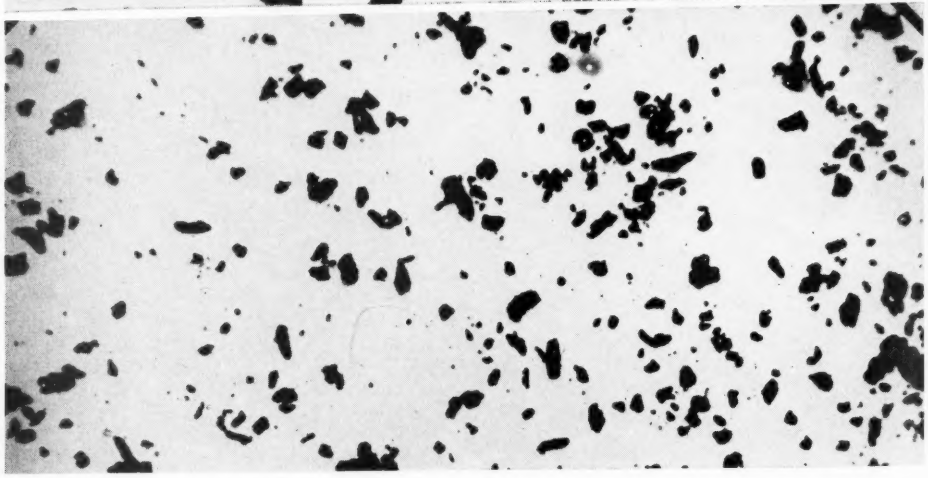


Fig. 5.—Particles of alloy D. (x90.)
Fig. 6.—Particles of alloy E. (x90.)
Fig. 7.—Particles of alloy F. (x90.)

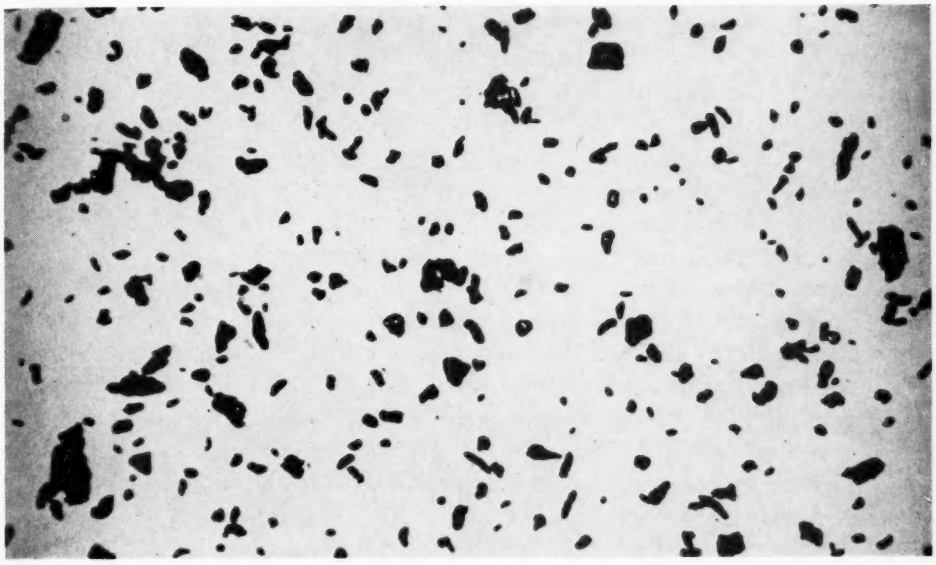


Fig. 8.—Particles of alloy G. (x90.)

was alloy G (Fig. 8). Alloy G in pellet form was presumably the same as alloy A. All of the alloys supposedly meet the requirements of the American Dental Association Specification No. 1.[2]

GENERAL PROCEDURE

An alloy-mercury ratio of 5/8 was employed throughout the study. Either the Wig-L-Bug or the S.S. White Mechanical Amalgamator were employed for the trituration as directed by the manufacturer.

The tests for dimensional change and flow were performed according to the directions specified in the American Dental Association Specification No. 1, with the exception that a temperature of 37° C. was employed (except as noted) instead of 20°-25° C. as directed in the specification.

The tests for compressive strength were performed with a newly calibrated Emery Testing Machine. Cylindrical specimens 4 by 8 mm. were employed. All results are the average of 3 to 5 tests. Values for compressive strength were obtained at the end of one hour and seven days after condensation.

At no time was the amalgam mix touched with the hands or otherwise contaminated.

METHOD OF CONDENSATION

A number of different condensation techniques were studied with the ultrasonic unit before a satisfactory method was found. The technique of expressing the mercury individually from small incremental pieces of mixed amalgam as they are condensed could not be employed satisfactorily with ultrasonic vibration. With such a method, a layering resulted between each increment condensed.

It became evident early in the study that speed during condensation was paramount. Furthermore, the amalgam to be condensed should be as "dry" of mercury as possible at the time of condensation, otherwise the condenser point skids or penetrates into the mass instead of condensing it. Also, a light pressure on the point was found to be indicated, to prevent a "chopping" of the amalgam and the generation of heat.

The method finally adopted for small mixes was to wring the entire mass of amalgam "dry" of mercury in a squeeze cloth and to place the amalgam under the vibrating point as rapidly as possible. For larger mixes, one-third to one-half of the mix was expressed at one time. The judgment and experience of the operator became a potent factor as to the amount of mercury to be expressed from the amalgam at one time. The important consideration was that the mercury be expressed and the amalgam condensed before any visible evidence of crystallization or hardening occurred. Only in this manner could a continuous amalgam structure without layering be attained. The actual time of condensation with the ultrasonic condenser should be approximately one-half that required for a *proper* amalgam condensation by hand.

As previously indicated, the condensation pressure with the ultrasonic unit was much less than that employed with hand condensation. For example, in the present research, 250 grams (0.6 lb.) of pressure were used with the special point (Fig. 1) in place of 3,600 grams (8 pounds) usually advocated for hand trituration. When the contra-angle points (Fig. 1) were used, the lightest possible pressure was employed.

As a rule, an intermittent application of pressure, as the point was pressed over the amalgam surface, was preferable to a continuous application. Under no circumstances should a burnishing action be employed.

EFFECT OF OUTPUT

The first variable to be studied was the effect of the output energy or amplitude of the ultrasonic vibration. The effect of the output on the dimensional change, flow, and compressive strength, as regulated according to the arbitrary dial settings on the instrument, is shown in Tables II to IV inclusive. Only four of the alloys were studied in detail in this regard. It was assumed that these alloys were sufficiently typical that any results obtained could be applied qualitatively to all alloys which meet the requirements of the American Dental Association Specification No. 1.

These properties for alloy B were determined for every 5 units of the dial setting, but the variations were so slight that 10-unit increments were used with the remaining alloys.

The properties obtained with a manual technique as directed by the respective alloy manufacturer are also included.

DIMENSIONAL CHANGE

The results obtained for the effect of ultrasonic output on the dimensional change are presented in Table II. In consideration of the units employed (microns

per centimeter), it is evident that the differences between the various data are not of considerable significance,* although the figures are experimentally significant with ±2 microns per centimeter. In general, the dimensional changes obtained with the ultrasonic condensation agree with those obtained with manual condensation, within the limits of experimental error.

TABLE II. EFFECT OF OUTPUT ON DIMENSIONAL CHANGE

OUTPUT SETTING	DIMENSIONAL CHANGE WITH ALLOY			
	A (μ/CM.)	B (μ/CM.)	C (μ/CM.)	D* (μ/CM.)
50	−3.1	+3.1	−3.9	+2.5
55		+3.0		
60	−2.6	+0.8	−5.4	+2.1
65		−1.1		
70	−1.1	−1.1	−4.0	−3.0
75		−0.7		
80	−4.0	+0.3	−5.7	+3.3
85		+2.3		
90	−2.8	+4.4	−4.4	+2.7
Hand cond.	−5.1	−1.1	−3.9	+5.8

*Point No. 33 used; special point used with alloys A, B, and C.

FLOW

The values obtained for flow are presented in Table III. These values can be assumed to be correct within ±1.0 per cent.

TABLE III. EFFECT OF OUTPUT ON FLOW

OUTPUT SETTING	FLOW FOR ALLOY			
	A (PER CENT)	B (PER CENT)	C (PER CENT)	D* (PER CENT)
50	9.0	4.7	8.1	8.5
55		3.9		
60	7.5	3.9	6.7	8.7
65		4.0		
70	6.5	3.0	8.6	7.3
75		4.1		
80	8.7	4.6	6.7	10.1
85		4.4		
90	5.9	4.9	7.9	9.7
Hand cond.	10.0	4.7	7.3	11.7

*Point No. 33 used; special point used with alloys A, B, and C.

In general, the flow values obtained with alloys A and D are lower with the ultrasonic condensation than with the manual condensation. There was no

*For the reader who is not familiar with the units employed, the data can be expressed in per cent by dividing by 100.

significant difference with the other two alloys between the flow values obtained with ultrasonic condensation and those obtained with manual condensation.

As with the dimensional change, the effect of the output setting is not particularly significant.

COMPRESSIVE STRENGTH

Because of the large variation in the magnitudes, it is difficult to estimate the experimental error of the results shown in Table IV. It is estimated that the values presented for the compressive strength obtained at the end of one hour are correct to within 7 per cent of each value, and those for the seven-day compressive strength are correct to within ±3 per cent of their value.

It is evident from the data in Table IV that the use of ultrasonic condensation definitely improves the compressive strength of the amalgam at the end of one hour. In the case of alloy D, the compressive strengths obtained with output settings 60, 70, and 80 are more than double the strength obtained with manual condensation.

TABLE IV. EFFECT OF OUTPUT ON COMPRESSIVE STRENGTH

OUTPUT SETTING	COMPRESSIVE STRENGTH FOR ALLOY							
	A		B		C		D*	
	1 HOUR (LB./IN.²)	7 DAYS (LB./IN.²)	1 HOUR (LB./IN.²)	7 DAYS (LB./IN.²)	1 HOUR (LB./IN.²)	7 DAYS (LB./IN.²)	1 HOUR (LB./IN.²)	7 DAYS (LB./IN.²)
50	12,900	40,100	19,600	65,300	13,300	52,700	12,600	54,000
55			15,700	57,500				
60	11,700	48,200	15,800	57,800	14,500	50,200	16,600	58,100
65			15,300	59,700				
70	16,300	52,500	19,700	61,100	13,700	45,500	17,300	59,900
75			17,300	56,300				
80	13,700	48,600	18,300	61,600	14,000	41,800	16,200	58,700
85			14,900	58,000				
90	14,200	48,200	21,100	57,900	10,400	45,800	12,500	55,600
Hand cond.	12,100	56,000	11,700	57,500	8,300	50,700	7,900	45,800

*Point No. 33 used; special point used with alloys A, B, and C.

The improvement in strength is less marked in the case of alloy A, although a noteworthy increase in strength at the end of one hour over that with hand condensation is noted with an output setting of 70.

The effect of the ultrasonic condensation on the strength at the end of seven days is somewhat erratic. In the case of alloy A, the seven-day strength of the amalgam was somewhat reduced when the ultrasonic method was used, regardless of the output setting. The same reduction can be noted for the amalgams made from alloy C with the higher output settings.

Amalgams made with alloy B using the ultrasonic method exhibit essentially the same or slightly higher strength at the end of seven days than that obtained with hand condensation. A substantial increase in strength at one week is gained

when ultrasonic condensation is employed with amalgams made with alloy D. This increase may be of importance, but it is doubtful that the differences in strength obtained with the other alloys are of clinical importance when one technique is compared with another.

OPTIMUM OUTPUT SETTING

There actually appears to be little choice clinically between any of the output settings. However, a tendency is present in the data to favor the output settings 70 to 80 inclusive. This tendency is especially marked in the case of the one-hour compressive strength values (Table IV) and the seven-day compressive strength values of amalgams made with alloys A, B, and D.

It is, therefore, assumed that the optimum vibrational energy for the condensation of amalgam is attained with an approximate output setting of 70-80 on the ultrasonic generator employed.

EFFECT OF AREA CONDENSER POINT

Assuming the optimum output setting to be 70, the effect of the area of the condenser point on the dimensional change, flow, and compressive strength was studied.

TABLE V. EFFECT OF CONDENSER POINT AREA ON DIMENSIONAL CHANGE (OUTPUT SETTING 70)

ALLOY	DIMENSIONAL CHANGE WITH CONDENSER POINT AREA			
	7.1 MM.² (SPECIAL) (μ/CM.)	3.1 MM.² (NO. 33) (μ/CM.)	1.8 MM.² (NO. 32) (μ/CM.)	0.8 MM.² (NO. 31) (μ/CM.)
A	−1.1	−1.8	−4.6	−5.9
B	−1.1	−0.3	−1.8	−3.2
C	−4.0	−3.6	−5.3	−7.9
D	+3.0	+3.0	+1.7	+2.0

As can be noted from Table V, the special condenser point and the point No. 33 are not greatly different in their effect on the dimensional change of the amalgams tested. However, when the smaller points Nos. 32 and 31 were employed, a tendency is evident toward a reduction in expansion or an increase in contraction.

The flow of the amalgam also was not greatly altered by the two larger points, but the smallest point (No. 31) produced a flow of considerable magnitude, with the exception of the amalgams made from alloy B (Table VI). That there may be an optimum size for the condenser point so far as the property of flow is concerned is evidenced by the fact that the lowest flow values were in general obtained with condenser point No. 32.

According to the data for compressive strength presented in Table VII, there is little difference between the effect of the special condenser point and the point No. 33. There is, however, a distinct trend toward a lower value for the com-

TABLE VI. EFFECT OF CONDENSER POINT AREA ON FLOW (OUTPUT SETTING 70)

ALLOY	FLOW WITH CONDENSER POINT AREA			
	7.1 MM.² (SPECIAL) (PER CENT)	3.1 MM.² (NO. 33) (PER CENT)	1.8 MM.² (NO. 32) (PER CENT)	0.8 MM.² (NO. 31) (PER CENT)
A	6.5	6.7	4.2	10.5
B	3.0	5.1	3.0	4.1
C	8.6	8.7	7.0	14.1
D	7.3	7.3	5.0	13.1

TABLE VII. EFFECT OF CONDENSER POINT AREA ON COMPRESSIVE STRENGTH (OUTPUT SETTING 70)

ALLOY	COMPRESSIVE STRENGTH WITH CONDENSER POINT AREA							
	7.1 MM.² (SPECIAL)		3.1 MM.² (NO. 33)		1.8 MM.² (NO. 32)		0.8 MM.² (NO. 31)	
	1 HOUR (LB./IN.²)	7 DAYS (LB./IN.²)	1 HOUR (LB./IN.²)	7 DAYS (LB./IN.²)	1 HOUR (LB./IN.²)	7 DAYS (LB./IN.²)	1 HOUR (LB./IN.²)	7 DAYS (LB./IN.²)
A	16,300	52,500	14,300	53,000	13,800	53,500	10,500	33,500
B	19,700	61,100	18,000	63,000	16,100	52,100	12,600	31,100
C	13,700	45,500	14,100	57,300	14,100	51,700	11,200	38,700
D	.....	.....	17,300	59,600	16,800	53,500	13,200	40,500

TABLE VIII. MISCELLANEOUS TESTS

PROPERTY	ALLOYS					
	E		F		G	
	HAND	ULTRASONIC*	HAND	ULTRASONIC*	HAND	ULTRASONIC*
Dim. Change (μ/cm.)	+12.4	+8.2	+5.4	+2.2	+6.0	+1.7
Flow (Per Cent)	16.2	13.6	5.0	3.4	10.3	8.9
Compressive Strength						
1 Hour (Lb./In.²)	9,700	14,500	11,500	14,700	10,800	16,900
7 Days (Lb./In.²)	50,500	58,700	54,900	60,800	48,300	57,800

*Output setting 70; condenser point No. 33.

pressive strength as the area of the condenser point is reduced below that of condenser No. 33. Undoubtedly, the low strengths obtained with condenser No. 31 after seven days are of clinical significance.

It was noted that it was almost impossible to prevent condenser No. 31 from penetrating the amalgam mass during the condensation. Undoubtedly, this point

churned or broke up the amalgam mass as it was applied, and thus the proper cohesion was prevented. It was for this reason that condenser points of less diameter than 1.0 mm. were found to be impossible to use effectively.

MISCELLANEOUS TESTS

The properties of three additional alloys have been tested with condenser point No. 33 and an output setting of 70, as shown in Table VIII.

As can be noted, the compressive strength of each amalgam at 1 hour after condensation is improved by the ultrasonic method in comparison to the manual technique. The flow values are reduced with the ultrasonic method, as well as the values for dimensional change.

TESTS AT ROOM TEMPERATURE

As previously noted, all tests for dimensional change and flow were performed at 37° C. (99° F.). Many investigators are interested in the results obtained for these properties when the tests are made at room temperature (20°-25° C.). The data obtained under such conditions of test for four of the alloys investigated are presented in Table IX.

TABLE IX. DIMENSIONAL CHANGE AND FLOW AT ROOM TEMPERATURE

ALLOY	METHOD OF CONDENSATION	DIM. CHANGE (μ/CM.)	FLOW (PER CENT)
A	Ultrasonic*	+2.1	3.1
	Hand†	+5.5	3.5
B	Ultrasonic*	+1.1	0.9
	Hand†	+4.1	1.6
C	Ultrasonic*	+0.6	3.4
	Hand†	+5.5	3.1
D	Ultrasonic*	+7.1	3.0
	Hand†	+10.8	4.6

*Output setting 70; condenser point No. 33.
†According to the directions of manufacturer.

SUMMARY AND CONCLUSIONS

The effect of the condensation of dental amalgam with a commercially available dental ultrasonic unit (Cavitron) has been studied with reference to dimensional change, flow, and compressive strength of the resulting amalgam. Seven commercially available amalgam alloys were investigated as to the effect of this technique.

According to the results presented, the following conclusions resulted:

1. The values for dimensional change and flow observed with the ultrasonic technique were not significantly different from those obtained with manual condensation.

2. At the end of one hour, the compressive strength of the amalgams condensed with the ultrasonic unit was definitely greater than the similar strength of manually condensed amalgam specimens. The differences in strength at the end of one week were generally not of clinical significance.

3. Although the "output settings" did not significantly effect the dimensional change and the flow values of the amalgams tested, the compressive strength values tended to be somewhat greater when "output settings" of 70-80 were employed.

4. Condenser points with a surface area of less than approximately 1.8 square millimeters appear to produce inferior properties of the hardened amalgam in comparison to the results obtained with condenser points of larger size.

RECOMMENDED TECHNIQUE

The following technique for the condensation of amalgam with ultrasonic vibration is recommended on the basis of the above findings.

1. Condenser points Nos. 33 and 32 are especially recommended. Point No. 31 should be used sparingly. Unfortunately, with the present ultrasonic unit, the exchange of condenser points during the condensation is not feasible due to the considerable time involved. This factor is a definite disadvantage from a clinical standpoint.

2. The amalgam mix should be squeezed free of mercury with a squeeze cloth and condensed as rapidly as possible. With large mixes 2 to 3 increments can be treated in turn.

3. The condensation pressure should be as little as is needed to keep the condenser point in intimate contact with the amalgam surface.

4. The field of operation should be kept absolutely dry during the condensation. The abrasive is not used.

5. The time for condensation should not be more than 2 to 3 minutes.

6. The optimum "output setting" is 70-80 for the condensation of amalgam with the ultrasonic unit employed

7. Other than the above-mentioned variations, the manipulation of the amalgam is as usual, according to the directions of the manufacturer.

REFERENCES

1. Heuter, T. F.: Some Techniques for Industry, Science **124**:787-792, 1956.
2. Paffenbarger, G. C., and Sweeney, W. T.: American Dental Association Specifications for Dental Materials, Chicago, 1956, The American Dental Association, p. 17.

Northwestern University Dental School
311 E. Chicago Ave.
Chicago 11, Ill.

SIXTH ANNUAL ESSAY CONTEST

Sponsored by
THE AMERICAN DENTURE SOCIETY

Prizes will be awarded to the two senior dental students who submit the best essays on prosthetic dentistry in the sixth annual essay contest sponsored by The American Denture Society. The purpose of the contest is to stimulate technical writing by dental students.

The first prize is Five Hundred Dollars ($500.00) and the second prize is Three Hundred Dollars ($300.00).

RULES

1. The contest is open to all senior dental students of the United States and Canada.
2. Only two essays may be submitted from any one dental college. (It is recommended that each dental college conduct its own contest to determine the two best essays submitted by members of its senior class.)
3. Essays are to be on some phase of prosthetic dentistry and limited to a maximum of 3,000 words.
4. Essays must be worthy of publication in the JOURNAL OF PROSTHETIC DENTISTRY and must be prepared in a form which is satisfactory to the requirements of that Journal.
5. The original essay and one copy must be submitted for the use of the judges.
6. Essays must be typewritten, double spaced, on a good grade of white bond paper 8½ by 11 inches. Paragraphs must be indicated clearly by indentations, and generous margins must be allowed on each page.
7. Illustrations must conform to the standards of the JOURNAL OF PROSTHETIC DENTISTRY, if they are used. Only good glossy black and white photographic prints or drawings in India ink may be used. Each illustration should be mounted on a separate sheet of paper with the figure number and the legend typed on the paper beneath the illustration.
8. The form and punctuation of references must conform to the style used in the JOURNAL OF PROSTHETIC DENTISTRY. The references must be keyed to the text material.
9. The permanent address of the author must be at the end of the reference page
10. The student has a free range in the choice of topics within the broad interpretation of prosthetic dentistry.

11. Essays will be judged on the basis of subject matter, neatness, composition, spelling, illustrations, charts and tables, number and accuracy of references, continuity of thought, and length of the essay.
12. The judges of the contest are members of a committee of The American Denture Society. The decision of the judges is final.
13. Essays are to become the property of The American Denture Society. None will be returned.
14. All essays submitted in the contest shall be clearly marked "Contest Essay" and shall be accompanied by a letter from the professor of prosthetic dentistry and/or the dean of the dental college from which they originate. This provision is to assure the authenticity of all essays entered in the contest.
15. Essays must be postmarked on or before July 15, 1958 and sent to:

Dr. Victor L. Steffel
Secretary, American Denture Society
College of Dentistry, Ohio State University
Columbus 10, Ohio

SPECIAL ANNOUNCEMENT

GLOSSARY RECOMMENDATIONS INVITED

The Glossary of Prosthodontic Terms, first edition, by the Academy of Denture Prosthetics, was published in the JOURNAL OF PROSTHETIC DENTISTRY, Volume 6, No. 2 (March), 1956. There has been much praise for the Glossary, which contains over 800 words and terms, and for the accomplishments of the Nomenclature Committee which coordinated the efforts of the Academy members and edited the publication. The Committee consisted of Carl O. Boucher, D.D.S., Chairman; Richard H. Kingery, D.D.S.; LeRoy E. Kurth,; D.D.S.; Victor H. Sears, D.D.S.; Vincent R. Trapozzano, D.D.S.; and Jack Werner, D.D.S.

In the preface to the first edition of the Glossary, the Nomenclature Committee stated:

"This, the first edition of the Glossary, is offered to the dental profession for its consideration. Since it is recognized that there are some terms which have not been included, and that some other terms and definitions which may be objectionable to some authorities have been included, revisions will be necessary from time to time. Constructive suggestions are invited, and these will be given thorough consideration in future editions. In its present form, this Glossary can serve as a good temporary standard."

Although constructive suggestions regarding revision of the Glossary were invited, very few have been received. This is a tribute to the skillful and meticulous manner in which the first edition was prepared.

The current Nomenclature Committee, consisting of Arthur R. Frechette, D.D.S., Chairman; Stephen G. Applegate, D.D.S.; and Frank C. Hughes, D.D.S., plan to present recommendations for revision of the Glossary to the Academy next April. For that reason, constructive suggestions are again invited. Revisions will involve the addition of terms not included in the original Glossary, deletion of certain obsolete or objectionable terms, and changes in definitions to clarify the meaning of some terms. It is particularly desired that suggestions for new or modified definitions include a proposed definition which is considered to describe clearly the term involved.

Communications should be addressed to the Chairman of the Nomenclature Committee, Captain Arthur R. Frechette (DC) USN, Bureau of Medicine and Surgery, Navy Department, Washington 25, D.C.

The Nomenclature Committee
Academy of Denture Prosthetics

READERS' ROUND TABLE

JACKSON HEIGHTS, N. Y.

EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

The recent article by Dr. Jarabak, "An Electromyographic Analysis of Muscular Behavior in Mandibular Movements From Rest Position" [J. Pros. Den. 7:682-710, 1957] is an interesting contribution to the study of maxillary-mandibular relations.

It is unfortunate that his use of the term "rest" on his records (Figs. 5,6,7,8,9,10, and 12) is associated with hyperactivity of muscles. The reader finds it difficult to tell whether the patient was commanded to rest or if it is the electromyographer's concept of rest.

The movement of voluntary muscles is controlled by conscious effort, habits, and reflexes. The purpose of establishing rest position is to eliminate the neuromuscular tensions that mask the reflex relations.

In the presence of hyperactivity of muscles (tension), a rest position is unattainable, and while individual muscles may appear silent, this should not be mistaken for physiologic rest position or erroneous conclusions may result.

Yours very truly,
HARRY SHPUNTOFF, D.D.S.

BIRMINGHAM, ALA.

EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

I am glad to hear that the JOURNAL OF PROSTHETIC DENTISTRY is going to include articles on operative dentistry. This is actually including still another branch of the broader field of prosthodontics, that of prosthetically restoring lost or damaged portions of individual teeth.

A tooth prosthesis, whether in the form of a filling or a more extensive restoration, is "the replacement of an absent part by an artificial one," as defined in the *Dorland Medical Dictionary*, just as truly as the replacement of missing teeth by bridge, partial denture, or complete denture. The practice of prosthodontics for the replacement of missing teeth in a partially edentulous arch of necessity involves individual tooth restorations either on abutment teeth or elsewhere in the arch if the mouth is to be adequately rehabilitated.

Sincerely yours,
WILLIAM L. MCCRACKEN, D.D.S., M.S.
Contributing Editor

SEATTLE, WASHINGTON

EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

. . . I am very pleased that the JOURNAL is going to include a section on operative dentistry. There seems to be a definite need for a periodical to include serious, stimulating articles on operative dentistry, and it would seem that the JOURNAL is the best medium for this.

Sincerely,
GERALD D. STIBBS, D.M.D.

INDIANAPOLIS, IND.

EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

. . . I am very pleased that additional emphasis will be placed upon operative dentistry in the JOURNAL as it certainly goes hand in hand with the type of material which has been published.

Sincerely yours,
RALPH W. PHILLIPS, M.S.

BOOK REVIEWS

ORTHODONTICS FOR DENTAL STUDENTS. By T. C. White, L.R.C.P. (Edin.), L.R.F.P.S., D.D.O. (Glas.), F.D.S.R.C.S. (Edin.), J. H. Gardiner, B.D.S., L.D.S. (Manc.), and B. C. Leighton, H.D.D. (Glas.), D.D.O., L.D.S.R.C.S. (Eng.), 367 pages, illustrated, indexed. London, 1955, Staples Press Limited, and New York, 1955, John de Graff, Inc. Price $8.00.

Following a conference of teachers of orthodontics held at Glasgow in 1952, the authors endeavored to fulfill the need for a textbook limited to the requirements of the undergraduate dental student. It is stressed in the preface that this work is in no way to be regarded as a standard textbook on orthodontics suitable for their studying for higher qualifications or for aspirants to specialist status.

The book has been divided into four basic parts as follows: Part I, Normal Growth and Development; Part II, Abnormal Development; Part III, Diagnosis; and Part IV, The Prevention and Treatment of Malocclusion.

The profusive use of illustrations has made a rather dry subject, namely anatomy, become a more understandable one. For example, Figs. 11 and 23 clearly illustrate the relationship of muscle forces upon the dental arches.

The authors have introduced several new terms to describe variations from the normal relation of the dental arches, or segments of the arches, to one another. Postnormal occlusion and prenormal occlusion allow greater latitude in describing these relationships than does the Angle classification.

Even though written for the undergraduate student, the part on Diagnosis is quite adequate. However, the section on Treatment is very good for not only the student, but also for the pedodontist and the general practitioner of dentistry. I believe the purpose of the book has been accomplished.

Benjamin H. Williams, D.D.S.

CLINICAL DENTAL ROENTGENOLOGY. By John Oppie McCall, D.D.S., F.A.C.D., and Samuel Stanley Wald, D.D.S., F.A.C.D. Fourth Edition, 466 pages, 1,445 illustrations, indexed. Philadelphia and London, 1957, The W. B. Saunders Company. Price $10.00.

This book is for the student, the dental hygienist, and the experienced dentist. It covers the production of roentgen rays, techniques of their use, safety precautions, developing methods, interpretation of roentgenograms, and diagnosis with their aid.

The material is described with the aid of a great many excellent illustrations. The writing is straightforward and easy to understand, without being vague as to meaning. The individual chapters are well organized, and the photographs are combined well with the written descriptions. The printing is on a good grade of glossy paper with good binding.

The chapters on the production of roentgen rays, their measurement, how they act, and the amount of radiation that can be tolerated are very good. The chapters on interpretation of roentgenographic findings of anomalies and pathology cover the subjects well. There is also an excellent discussion of the merits of the long and short cone techniques, their advantages and disadvantages. However, the book is weak on the techniques for the general practitioner to make special roentgenographic studies.

For the person who starts at the beginning and reads through the book for all the information he can get, it may seem to be put together in a confusing fashion. However, the authors have covered the subject well, and for the person who knows how to use the index and wishes to use the book for reference, it will serve the purpose for which it was intended.

James B. Boucher, D.D.S.

NEWS AND NOTES

MEETINGS

Dallas Mid-Winter Dental Clinic, Statler Hilton Hotel, Dallas, Texas, Jan. 26 to 29, 1958.

American Equilibration Society, Sheraton-Blackstone Hotel, Chicago, Ill., Jan. 30, 1958.

American Denture Society, Congress Hotel, Chicago, Ill., Jan. 31 and Feb. 1, 1958.

American Academy of Crown and Bridge Prosthodontics, Conrad Hilton Hotel, Chicago, Ill., Feb. 1 and 2, 1958.

American Academy of Restorative Dentistry, Conrad Hilton Hotel, Chicago, Ill., Feb. 1 and 2, 1958.

American Association for Cleft Palate Rehabilitation, St. Francis Hotel, San Francisco, Calif., April 24 to 26, 1958.

This Association is composed of medical, dental, and paramedical specialists who are interested in the rehabilitation of persons with cleft lips and palates.

Academy of Denture Prosthetics, Statler Hotel, Detroit, Mich., May 5 to 9, 1958.

ANNOUNCEMENTS

Tufts University School of Dental Medicine announces the following postgraduate refresher courses:

Occlusal Equilibration, Feb. 10 to 12, 1958.

Periodontics, Feb. 26 to 28, 1958.

Crown and Bridge Prosthesis Participation Course, Feb. 28, March 1, 7, 8, 14, 15, 22, 29, 1958.

Occluso-rehabilitation, March 3 to 7, 1958.

High Speed Instrumentation for the Preparation of Cavities, March 17 to 19, 1958.

Diagnosis and Management of Occlusal Disharmonies, April 7 to 9, 1958.

Participation Course in Periodontology, April 14 to 18, 1958.

For further information write to, Director of Graduate and Postgraduate Studies, Tufts University School of Dental Medicine, 136 Harrison Ave., Boston, Mass.

Northwestern University Dental School announces the following postgraduate courses:

A Practical Approach to the Use of Gold Foil, Jan. 22 to 24, 1958.

Basic Oral Surgery, Jan. 27 to 31, and March 17 to 21, 1958.

Clinical Efficiency of High Speed Cutting Devices, Jan. 29, 1958.

Use of High Speed Instrumentation and Its Effect on the Dental Tissues, Jan. 30 and 31, 1958.

Endodontics, Feb. 24 to 26, 1958.

Use of Elastic Impression Materials, March 31 to April 2, 1958.

Complete Denture Procedures in General Practice, April 2 to 4, 1958.

Prosthetic Rehabilitation for the Cleft Palate Patient, April 7 and 8, 1958.

Clinical Features of Oral Lesions, April 16 to 18, 1958.

The Use of Drugs in Dental Practice, April 30 to May 2, 1958.

Diagnosis, Roentgenography, and Treatment Planning, May 5 to 7, 1958.

Conference for Teachers of Pedodontics, June 9 and 10, 1958.

For further information and application, write to Director of Dental Postgraduate Study. Northwestern University Dental School, 311 East Chicago Ave., Chicago 11, Ill.

The Medical College of Virginia, School of Dentistry, announces the following postgraduate courses:

Crown and Bridge Prosthodontics, Feb. 17 to 19, 1958.
Partial Denture Design, Feb. 26 to 28, 1958.
Complete Denture Construction, March 3 to 8, 1958.
Oral Diagnosis, March 10 to 14, 1958.
Anatomy of the Head and Neck, March 17 to 21, 1958.
Oral Surgery, March 31 to April 2, 1958.
Periodontology, April 14 to 16, 1958.
Roentgenology, April 21 to 23, 1958.

For further information and application, write to Dr. H. T. Knighton, Medical College of Virginia, School of Dentistry, Richmond 19, Va.

Temple University School of Dentistry announces the following postgraduate courses:

Periodontal Prosthesis, Dr. Morton Amsterdam and Dr. Walter Cohen, Feb. 10 to 14, 1958.
Practice Administration, Dr. Jay H. Eshleman, Feb. 15, 1958.
Advanced Surgical Techniques in Periodontal Therapy, Dr. Saul Schluger, April 21 to 25, 1958.
The Washed Field Technique in Accelerated Dentistry, Dr. E. O. Thompson, May 5 and 6, 1958.
Endodontics—Immediate Root Resection, Dr. Louis Grossman and Dr. Leonard Parris, June 3 to 7, 1958.
The Porcelain Jacket Crown, Dr. Joseph Ewing, June 11, 12, 18, 19, and 25, 1958.

For further information and application, write to Dr. Louis Herman, Postgraduate Division, Temple University School of Dentistry, 3223 North Broad Street, Philadelphia 40, Pa.

Emory University, School of Dentistry, announces the following postgraduate courses:

Occlusion, Dr. Sigurd Ramfjord, Feb. 3 to 7, 1958.
Posterior Crown and Bridge Prosthodontics, Dr. George H. Moulton and Staff, March 5 to 7, 1958.
Pedodontics, Dr. Ralph L. Ireland and Staff, April 23 to 25, 1958.
Refresher Course in Immediate Denture Prosthesis, Dr. L. B. Brown, Dr. H. J. Harpole, Dr. J. C. Garland, and Dr. Parker E. Mahan, May 8, 1958.

For further information, write to Emory University, School of Dentistry, 106 Forest Ave., N. E., Atlanta 3, Ga.

The Western Reserve University, School of Dentistry, announces the inauguration of a continuing series of postgraduate courses.

The first course will be Psychodynamics and Practice Administration in Dentistry by Dr. Lloyd N. Hollander and Staff, April 21 to 23, 1958.

For further information, write to, Dr. Philip Burwasser, Director of Post-Graduate Education, School of Dentistry, Western Reserve University, Cleveland 6, Ohio.

Beth Israel Hospital Dental Department announces a postgraduate course in Periodontics to be given March 17 to 28, 1958, by Dr. Henry M. Goldman and Dr. Bernard Chaikin.

For further information, write to Director of Public Relations and Education, Beth Israel Hospital, 330 Brookline Ave., Boston 15, Mass.

The Sterling-Rock Falls Rehabilitation Center, Rock Falls, Illinois, announces a one-month course in maxillofacial prosthetics to be held Aug. 4 to 29, 1958.

For additional information, write to Edwin N. Cooper, Executive Director, Sterlng-Rock Falls Rehabilitation Center, 303 West 2nd St., Rock Falls, Ill.

The University of Alabama, School of Dentistry, announces the following refresher courses:

Nutrition and Dentistry, Feb. 1 to 3, 1958.

Periodontology for the General Practitioner, Feb. 8 to 10, 1958.

Preventive Orthodontics, Feb. 15 to 17, 1958.

Laboratory Procedures in Crown and Bridge Prosthesis for the General Practitioner, Feb. 22 to 24, 1958.

Occlusal Adjustment: Its Relation to Dental, Periodontal, and Temporomandibular Joint Problems, March 1 to 3, 1958.

Applied Maxillofacial Anatomy, March 8 to 10, 1958.

Root Canal Therapy, April 12 to 14, 1958.

Pedodontics for the General Practitioner, April 19 to 21, 1958.

Complete Denture Prosthesis, May 4 to 6, 1958.

Management of Infections in Dental Disease, May 10 to 12, 1958.

Surgical Anatomy of the Head and Neck, May 17 to 19, 1958.

For further information and application, write to Dr. Arthur H. Wuehrmann, University of Alabama, School of Dentistry, Medical Center, Birmingham 3, Ala.

The Ohio State University, College of Dentistry, announces the following postgraduate courses:

Review of Dental Hygiene (For Hygienists), Staff, Jan. 27 to 29, 1958.

Crown and Bridge, Dr. Thomas F. McBride, Feb. 10 to 14, 1958.

Complete Denture Prosthodontics, Dr. Carl O. Boucher, Feb. 17 to 21, 1958.

Partial Denture Prosthodontics, Dr. Victor L. Steffel, Feb. 24 to 28, 1958.

Pedodontics, Dr. Lyle S. Pettit and Dr. Benjamin H. Williams, March 3 to 7, 1958.

Oral Pathology, Dr. Hamilton B. G. Robinson, March 10 to 14, 1958.

General Anesthesia, Dr. Morgan L. Allison, April 28 to May 2, 1958.

Periodontics, Dr. John R. Wilson, May 5 to 9, 1958.

Review of Clinical Dentistry, Staff, May 12 to 16, 1958.

Pharmacology, Dr. William R. Kampfer, May 19 to 23, 1958.

For further information and application, write to Postgraduate Division, The Ohio State University, College of Dentistry, Columbus 10, Ohio.